Castorseed & Its Products
Proceedings of the Seminar
Held on the 11-12, Aug.
1960 at the Regional
Research Instt.
Hyderabad.

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CASTORSEED & ITS PRODUCTS

Proceedings of the Seminar
Held on the 11th & 12th August 1982 at the
Regional Research Laboratory, Hyderabad

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&
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Published by the
Indian Central Oilseeds Committee,
Hyderabad.

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Published by Dr. R. Sankaran, M.A., PH.D. (LONDON) D.I.C., Secretary, Indian Central Oilseeds Committee, Gandhi Bhavan, Hyderabad (Dn.)
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PREFACE

A two-day seminar on "Castorseed and its Products" was held on August 11-12, 1960, at the Regional Research Laboratory, Hyderabad, under the sponsorship of the Council of Scientific and Industrial Research, India.

In order to consider the various factors bearing on the present and future of the castor industry as it relates to India, a number of questions likely to arise were first formulated under suitable heads. These were sent to a large number of Research Institutions, organisations dealing with castor and firms, either processing castor or utilising its products, especially castor oil. Data or information illustrating and amplifying the questions raised were requested. The data received in the form of brief notes were arranged suitably under the different heads. These questions and notes were then sent round to all the organisations for thorough study, ensuring that the discussions at the actual venue would be well-informed and fruitful.

At the three sessions, Dr. J. G. Kane, Dr. N. G. Chatterji and Dr. R. Sankaran conducted the progress of the discussions. The entire material has now been brought together in this booklet. It includes the questions raised, the notes received and the discussions which later took place at the sessions. Though the seminar dealt primarily with castor in its Indian setting, the material in this booklet might well have a wider interest.

The seminar was organised by Shri Baldev Singh, Liaison & Information Officer of this Laboratory and his team of colleagues. The data and discussions were put together in a form suitable for publication by Dr. K. T. Achaya, Officer-in-charge, Oils and Fats Division, assisted by Shri G. M. Sastry and Shri N. S. Rajagopal. The booklet has been printed and published through the enthusiastic efforts of Dr. R. Sankaran, Secretary, Indian Central Oilseeds Committee, to whom our grateful thanks are due for the quick and tasteful execution.

S. Husain Zaheer

Director

Regional Research Laboratory, Hyderabad.

January 1961.

Delegates to the Seminar

N. M. Aggarwal	*Gordhandas Mangilal Oil Mills, Chalisgaon (East Khandesh).*
Arvind Pershad	*Proprietor, Rajendra Oil Mills, Azamabad, Hyderabad-20.*
Atma Ram	*Oil Expert to the Government of Uttar Pradesh, Harcourt Butler Technological Institute, Kanpur.*
N. G. Chatterji .. .	*Representative, Oil Corporation of India (Pvt.) Ltd., Chittaranjan Avenue, Calcutta.*
V. B. Chipalkatti	*Director, Shri Ram Institute for Industrial Research, 19 University Road, Delhi-8.*
K. K. Dole	*Professor of Chemistry, Fergusson College, Poona.*
W. P. Joshi ..	*Proprietor, J. P. & Co. Soap Works, Azamabad, Hyderabad-20.*
J. G. Kane	*Professor, Department of Chemical Technology, University of Bombay, Matunga, Bombay-19.*
P. N. Kathju	*Industrial Liaison Officer, (Council of Scientific and Industrial Research), 62 Sarojini Marg, Jaipur (Rajasthan).*
R. K. Kochhar ..	*Shri Ram Institute for Industrial Research, 19 University Road, Delhi-8.*
K. Krishnamurthy .	*Central Food Technological Research Institute, V. V. Mohalla P.O., Mysore.*
R. G. Krishnamurthy	do.
D. Krishnamurti	*Director, The Aryan Industries (Pvt.) Ltd., Walker Town, Secunderabad-3.*
J. P. Kubhustha	*Entomologist, Regional Research Centre for Oilseeds (Indian Council of Agricultural Research), Himayatsagar Farm, Hyderabad-8.*
B. S. Kulkarni . ..	*Head of the Department of Chemical Technology, Osmania University, Hyderabad-7.*
L. G. Kulkarni	*Head, Regional Research Centre for Oilseeds (Indian Council of Agricultural Research), Himayatsagar Farm, Hyderabad-8.*
D. M. Merchant ..	*Director, Bhavnagar Oil and Chemical Industries Ltd. P. B. No. 1611, Bombay-1.*

K. S. Murti	*Principal, Oil Technological Institute, Anantapur (Andhra Pradesh).*
M. P. Narasimha Rao ..	*Oilseeds Specialist, Rajendranagar, Hyderabad-8.*
M. Narayana Rao	*Central Food Technological Research Institute, V. V. Mohalla P. O., Mysore.*
Y. Nayudamma ..	*Director, Central Leather Research Institute, Adyar, Madras-20.*
V. Neelkant	*Chemist, Kapadia Oil Mills and Refinery, Azamabad, Hyderabad-20.*
H. Nizamuddin	*Reader, Department of Chemical Technology, Osmania University, Hyderabad-7.*
Laljee G. Palau	*Kapadia Oil Mills and Refinery, Azamabad, Hyderabad-20.*
H. A. B. Parpia	*Industrial Liaison and Extension Officer, Council of Scientific and Industrial Research, Old Mill Road, New Delhi.*
N. V. V. Parthasarathi ..	*National Research Development Corporation of India, Mandi House, Lytton Road, New Delhi.*
J. S. Patwari	*Department of Chemical Technology, Osmania University, Hyderabad-7.*
S. Y. Phadke	*Chemist, Gwalior Oil Mills, Bombay.*
T. S. Ramaswamy	*Research Chemist, Tata Oil Mills Co. Ltd., Sewri, Bombay-15.*
M. R. Rao	*Chemist, Standard Flour and Oil Mills (Pvt.) Ltd., Ganj-Baroda (M. P.)*
M. M. Ravi ..	*Chief Chemist, Hyderabad Chemical and Pharmacentical Works Ltd., Azamabad, Hyderabad-20.*
H. G. R. Reddy	*Development Wing, Ministry of Commerce and Industry, New Delhi.*
V. Samuel	*Development Chemist, Standard Vacuum Oil Co., Bombay-1.*
R. Sankaran	*Secretary, Indian Central Oilseeds Committee, Gandhi Bhavan, Hyderabad-1.*
M. K. Shah	*Kilachand Devchand & Co. (Pvt.) Ltd., C/o. Kesar Sugar Works Ltd., 45-47 Apollo Street, Bombay.*
W. Thirumala Rao ..	*Agricultural Chemist, Rajendranagar, Hyderabad-8.*
V. L. Shah ..	*Lalji Poonsi & Co., 3 Chinok Bunder Road, Bombay-9.*

L. S. Vaidya . . *Department of Chemical Technology, Osmania University, Hyderabad-8.*

P. Vallabhji . . . . *Representative, Premji Haridas & Co., 168 Argyel Road, Bombay-9.*

K. R. Varma . . . . *Research Chemist, The Tata Oil Mills Co. Ltd., Sewri, Bombay-15.*

Members of the Regional Research Laboratory, Hyderabad, attended the sessions, and the following participated in the discussions :

K. T. Achaya
J. S. Aggarwal
Bharat Bhushan
N. Bhojraj Naidu
S. Zainul Abideen
K. S. Chari
M. C. Menon
H. Shripathi Rao
M. A. Sivasamban

WELCOME ADDRESS

by

S. Husain Zaheer

Director, Regional Research Laboratory, Hyderabad

Shri Pattabhirama Rao, Ladies & Gentlemen:

It is my pleasure to welcome you all to a two-day seminar on "Castorseed and its Products." It is an encouragement to us that Shri Pattabhirama Rao, who is the Chairman of the Executive Council of this Laboratory, has graciously consented to inaugurate this seminar. His ready acceptance despite a busy round of duties is a reflection of his interest in our welfare, and we offer him a warm welcome here.

The genesis of this seminar is not far to seek. Till recent years, the Indian production of castorseed oil which amounts to some 10,000 tons was exported almost in its entirety to the United States of America. The other country also exporting to America was Brazil, but the total American demand was sufficient to absorb the oil both from India and from Brazil. Several things occurred to upset this rather complacent pattern. Brazil was able to sell its oil in America at a lower price than India. It would also appear that the Indian prices were somewhat high, perhaps for more reasons than one. And lastly, the United States of America, realising the value of the castor crop, commenced to grow it in a fairly big way, and last year was able to produce about one-fifth of its requirements. Clearly, the comfortable situation to which we have grown accustomed in respect of castor oil was likely to be rudely upset. It seemed worthwhile to examine the castor picture in its many aspects, except the agricultural aspect of acreage and yields which are adequately covered by agricultural bodies. The non-agricultural aspects include the processing of castor, uses of by-products, the quality of products, the price pattern of the commodity, and perhaps most important of all, the new uses for the major product, castor oil. For this sort of survey, the usual reading of research papers was obviously not the best method. Accordingly, we thought it expedient to obtain as much factual information as possible on the basis of a series of questionnaires which were distributed rather widely. The response was gratifying, as can be seen from the folder containing the collected material which has been sent to most of you. We are indeed grateful to those of you who have taken the trouble to compile the data or information in your knowledge and sent them to us in time to be printed. I hope the discussions arising out of this basic data can now be truly informative and purposive.

The title "seminar" has been deliberately chosen since this is not a symposium in the conventional sense of the word but rather a discussion forum.

Also, we have tried to bring together at this meeting a wide, rather than a large, cross-section of individuals and organisations, whose interests all centre in one fashion or another on castor. From these numerous and perhaps even conflicting viewpoints may emerge an integrated course of action which will stimulate the castor industry. The Indian Central Oilseeds Committee also, aware of the changing castor situation, has itself appointed a Sub-Committee with the same basic objective as that of this seminar. I hope the present data and deliberations will be of value to the decisions of that body.

It was my pleasure about 20 months ago to welcome a similar gathering to a symposium on "Cottonseed and its By-Products". I see a number of the same faces here today. This is a matter of pleasure since it perhaps indicates that the earlier symposium had something positive to contribute which has drawn these delegates again. With cottonseed we were dealing with a comparatively new oilseed. Castor, on the other hand, is a product of long standing, and the problem is one of better ways of utilisation of already-existing products with more or less well-established uses. By the wizardry of modern science, basic raw materials can be transformed out of recognition. Thus with castor oil we have such diverse uses as the production of jet engine lubricants, surface coatings, surface-active agents, nylon and perfumes. Naturally, all these cannot be started in the country at a day's notice. Often, the technical know-how is lacking, or in other instances the ancillary commercial industries or consuming public may still have to be developed. But we can put our minds at this seminar to the avenues most likely to lead to fruitful results in the near future. For example, we have a large and established textile industry which can absorb a fair amount of synthetic wetting agents and detergents. Such products derived from castor oil might have a more immediate chance of utilisation than certain others.

Our experience at the earlier "Cottonseed Symposium" showed that the organisation should be such as to make certain of two elements, at least. Firstly, the data forming the basis of discussions should be disseminated as early as possible in an appealing form, and secondly a discussion leader was essential to guide the deliberations with a firm but gentle hand. It gives me particular pleasure to thank Dr. J. G. Kane, Dr. N. G. Chatterji and Dr. R. Sankaran who have given their valuable time and experience to act as discussion leaders during the next two days. On my own behalf, I should also like to thank my younger colleagues in this Laboratory who have organised this seminar largely on their own initiative and mostly during my absence abroad. Once again, I welcome you all and wish you fruitful deliberations during the ensuing sessions.

INAUGURAL ADDRESS

by

S. B. P. Pattabhirama Rao

Minister for Education, Government of Andhra Pradesh

Dr. Husain Zaheer and Friends :

It is my pleasant duty to inaugurate this seminar this morning. I am particularly happy to be present here for this inauguration, because I am interested in the problem of castor for three reasons. Firstly, I happen to be the Chairman of the Executive Council of the Regional Research Laboratory at Hyderabad and naturally I am keen on the development of castor-seed, its products, its economics, etc. Secondly, Andhra Pradesh with nearly 9 lakh acres under castor, produces about half the castor grown in the country. India and Brazil are the two major castor-producing countries in the world and till recently almost all the castor oil produced in India used to be exported to the United States of America, securing the much-needed hard currency. And thirdly, the castor trade recently received a jolt from foreign competition ; Brazil by its proximity to the United States of America as well as by export subsidy has captured the United States market. Added to this, the United States itself has turned her eye on castor production and last year grew about 20 per cent of her requirement. Today, therefore, both the scientific and economic aspects of this cash crop, castor, command our immediate attention. All the same, there is nothing to be scared of in the present situation even though we may be gradually losing our castor trade.

All these days we have been exporting castor oil with its unpleasant odour, from which all of us ran away during our childhood. But now we will have to explore the possibilities of further utilisation of castor oil for the manufacture of more useful industrial products. I am told that castor oil can be used for the manufacture of lubricants for jet engines, nylon, perfumes, synthetic wetting agents and so on. I am sure the scientists and technologists assembled here would help the utilisation of the surplus castor in the country for a better and more valuable industrial product. May be, the temporary loss of our foreign market can be turned to our economic advantage. I hope that our once colonial economy of exporting raw materials and importing finished products would be transformed into an industrial economy, though this will take a long time. To this end, I am confident that the present assembly of technologists will work wholeheartedly. It is they who should find us a solution to our problems.

The State Government also has been taking steps to improve the quality of oilseeds as well as to increase production through a number of schemes included in the State Plan. The oilseeds development scheme, the oilseeds

extension scheme, the upgrading of the Agricultural Research Station at Nandyal are all designed to augment oilseeds production, including castor. This is to be done through organisation of oilseed farms, and intensive propaganda for and demonstration of the use of improved seed, adequate manuring, proper intercropping, plant protection measures and improved methods of cultivation. In the Third Plan too, we have several schemes: to run two zonal nucleus seed farms for the production of groundnut and castor seeds; to establish a Research Station on oilseeds development and extension schemes; and to test and demonstrate the response of castor to chemical fertilisers. We expect that total production of all oilseeds, including castor, will increase by about 1.5 lakh tons during the Third Plan. It will be your job to find out ways and means for effective utilisation of all this oil in the manufacture of industrial products.

I am very happy to find that our Laboratory at Hyderabad had taken up the task of organising the seminar in this city and for this, our thanks are in no small measure due to Dr. Zaheer, the Director. I would request you now to go ahead with the more serious job of discussing your technical problems.

Thank you.

VOTE OF THANKS

by

BALDEV SINGH

Regional Research Laboratory, Hyderabad

Shri Pattabhirama Rao, Dr. Zaheer, Delegates to the Seminar, Ladies and Gentlemen :

It gives me great pleasure to propose a vote of thanks.

I should first like to thank Shri Pattabhirama Rao for very kindly accepting our invitation to inaugurate this seminar, despite the busy life that a minister has to lead. We are grateful that he could find the time to be with us today. Next, I should like to thank the delegates to the seminar who have very kindly responded to our invitation and come to Hyderabad to participate in the deliberations. We have been experimenting with the technique of organisation of these deliberations in our last symposium on "Cottonseed and its By-Products" held in December 1958. We had then invited research papers, and circulated them in advance ; at the symposium itself only discussions based on these papers took place. This time, we have not invited any research papers at all, but tried to collect the maximum information on all aspects of castor and its products. This procedure seemed appropriate for the subject of this seminar. This information has been made available in the form of a brochure to all of you. I hope you will find this approach conducive to fruitful discussion. We sincerely hope that fresh ideas on the subject will come up and that the seminar will result in some benefit to research and to the industries connected with castor.

I should like to extend our cordial thanks to three firms in this city—*viz.* Biological Products, Hyderabad Chemicals and Pharmaceuticals, and Aryan Industries—for their very kind contribution towards the expenses of the 'At Home' being arranged this evening. We look forward to increasing collaboration with them in the field of research and we hope that this association will be profitable both to them and to the Laboratory.

I shall be failing in my duty if I do not convey my gratitude to my colleagues in this Laboratory who are responsible for bringing out the advance brochure, and to the Cafeteria Committee and other members of the staff who have extended their co-operation in the organisation of the seminar. Lastly I should like to extend my thanks to you all, ladies and gentlemen, for having responded to our invitation to attend this function today and make it a success.

SECTION A

CASTOR OIL

DISCUSSION LEADER : *Dr. J. G. Kane,*
Department of Chemical Technology,
University of Bombay,
Bombay.

SECTION A

CASTOR OIL

Questions Raised

1. *What are the present uses of castor oil in India, percentage-wise and tonnage-wise? Could any of these be stepped up by making improved products (e.g. improved DCO)?*

2. *What is the tonnage of dehydrated castor oil produced in India? What are the uses to which it has been put? What is the tonnage used in the paint industry* vis-a-vis *other drying oils?*

3. *What are the reasons for dehydrated castor oil not enjoying greater popularity than at present?*

4. *What are the present uses of castor oil in the U. S. A.?*

5. *Can any of these newer uses be started immediately in India? Do we have enough technical know-how? What is the demand for products under these new outlets in India and abroad?*

6. *Are there any other known fields, such as those mentioned below, in which the use of castor oil can be investigated, where an Indian-made product would undersell a foreign?*

   (*a*) *Perfumes (type, quantity used, economics of production).*

   (*b*) *Lubricants (types using castor oil, quantities used, costs).*

   (*c*) *Detergents (Turkey Red oil, quantities used in India and abroad, prices).*

   (*d*) *Foams (types, basis of use of castor oil, work being done abroad).*

   (*e*) *Hydrogenated castor oil (use in lubricant greases and as a dispersing agent in paints).*

7. *What are the items above needing research (laboratory or cost-engineering)? Are they worth doing? Would industry aid such research financially?*

8. *What are the present research lines on castor oil in India which are complete, in progress or to be taken up very soon, which may have practical value as an outlet for castor oil within the country?*

Notes Received

Uses of Castor Oil in India and Possibilities

1. Castor oil is used in India for axle lubrication, manufacture of paints, etc., textiles, leather, etc., and medicines.

(*Ministry of Commerce & Industry, New Delhi*)

2. 5000 tons of castor oil are used for preparing Turkey Red oil, about 3000 tons for the manufacture of soap, 2000 tons for the manufacture of refined and perfumed hair oil, 1000 tons for the manufacture of disinfectants, 2000 tons for medicinal purposes.

(*Laxminarayan Inst. of Tech., Nagpur*)

3. Castor oil is mainly used in India for the following : (1) Illumination (2) Lubrication (3) Emollient for skins and leathers (4) Turkey Red oil (5) Dehydrated castor oil (6) Hydraulic brake fluid (7) Soaps, cosmetics, pharmaceuticals. Foreign export of these products should be possible.

(*K. K. Dole, Poona*)

4. Preparation of an improved DCO may step up consumption of castor oil for this purpose. Manufacture of water-white DCO fatty acids may also result in some sales, but nothing definite can be stated now. The production and consumption of monomeric dehydrated castor oil should also increase the sales.

(*Swaika Oil Mills, Calcutta*)

5. It should be possible to process castor oil into nylon-intermediate or nylon itself in India.

We have no precise data in regard to the uses of castor oil for the manufacture of detergent foams, lubricant greases, etc. *vis-a-vis* the prices of foreign products. The prospects of processing castor oil into nylon intermediate or nylon would be of interest to the industry.

(*Ministry of Commerce & Industry, New Delhi*)

Use of Castor Oil in the U. S. A.

1. Castor oil is used in the U. S. A. in many fields : Castor oil-based urethanes ; preparation of perfumery products such as amylcinnamic aldehyde from heptaldehyde for soap perfumes (1,25,300 lb. in 1947); heptyl alcohol and its esters ; oenanthic or heptoic acid and its esters. Another important material from heptaldehyde is nonalactone, and acetals of the heptaldehyde. Undecalactone from undecylenic acid and esters of undecylenic acid are useful ingredients of both perfumes and flavouring essences.

Nylon-11 is made commercially in France and Italy for use in plastics and fibres. Sebacate lubricants, paints, varnishes and resins, etc. are useful products.

(Laxminarayan Inst. of Tech., Nagpur)

2. Castor oil is mainly used in the U. S. A. for the following : (1) Adhesive cements (2) Alkyds (3) Plasticizers (4) Cutting, dielectric or condenser oils (5) Greases and lubricants (6) Dehydrated castor oil (7) Cosmetics and pharmaceuticals (8) Printing inks, polishes and waxes (9) Rubber and rubber substitutes, etc.

(K. K. Dole, Poona)

3. The important industrial uses of castor oil in the U. S. A. are :

(a) In the manufacture of sulphonated castor oil (also known as Turkey Red oil). This oil is used in textile printing and for finishing cotton, linen, silk and leather.

(b) Castor oil is used in the manufacture of certain varieties of soaps, imitation leather, fly-paper, typewriter inks and special lubricants.

(c) Castor oil was formerly used for lubricating aircraft motors. Mineral oil has now replaced castor oil for this purpose.

(d) Considerable quantities of castor oil are used in the manufacture of nitrocellulose baking finishes and hydraulic brake fluids.

(e) Sebacic acid is manufactured in the U. S. A. by high-temperature fusion of castor oil with caustic soda. Sebacic acid is also one of the raw materials required for the synthesis of nylon.

(f) Large quantities of castor oil are converted into dehydrated castor oil which is sold as drying oil under various trade names for use by paint, enamel and varnish manufacturers. Dehydrated castor oil is used in the manufacture of oiled fabrics, linoleum, patent leather, printing ink and lithographic varnishes. Dehydrated castor oil accounts for nearly a third of the total consumption of castor oil in the U. S. A.

(g) Castor oil is used for medicinal purposes as a purgative. Hydrogenated castor oil is sulphonated and used in the preparation of ointments.

(h) Castor oil is freely soluble in alcohol and is used in the preparation of alcoholic hair lotions. Castor oil is also used as a raw material in the manufacture of aromatic perfumes.

(Ministry of Commerce & Industry, New Delhi)

4. Some aspects of the uses of castor oil in the U. S. A. are given below :

(*a*) *Distribution of uses of castor oil in the U. S. A. in 1958 :*

	Million lb.	%
Surface coatings	56	45
Plastics & plasticisers	24	19
Lubricants	17	13
Surfactants	9	7
Hydraulic fluids	6	5
Cosmetics and pharmaceuticals	2	2
Miscellaneous	11	9
Total	125	100

(b) *Urethane foams.* Development work is in progress on the use of castor oil to produce urethane foams (which resemble rubber latex foams) by reacting isocyanates, made by Du Pont and Mowbay, with compounds containing oxygen. About 75 million lb. of such urethane foams are produced annually in the U. S. The majority of these are rigid-type foams which are derived from cheap raw materials (polyethers, made by Dow, Union Carbide and Atlas Powder Company). At present this constitutes 93% of all polyurethane foams. The remaining 7% of polyurethane foams are of the flexible type which are used for furniture, automobiles, mattresses, etc. Research work is in progress to use castor oil for producing such flexible foams by reaction with isocyanate.

(c) *Use of sebacic acid in jet aircraft.* 20,000 tons of castor oil are being used in the U. S. A. to prepare by alkali fusion some 9,000 tons of sebacic acid, of which 7,000 tons are used for preparation of nylon and plasticizers and 2,000 tons to make dioctyl sebacate (di-2-ethylhexyl-sebacate). Dioctyl sebacate is used as a lubricant in jet aircraft since it maintains its viscosity at temperatures varying from —65° to +400° C. This use is likely to continue and to extend, since most civilian airlines in the U. S. A. are also taking to turbo-jet and turbo-prop aeroplanes. There is also a possibility of use in motor cars as hydraulic brake fluids, transmission fluids and crankcase oils. They may also find use in the new ashless detergents which are added to ordinary mineral oils to get improved detergency and improved viscosity. The cost of dioctyl sebacate in the U. S. A. is 60 cents per lb. and of sebacic acid 69 cents per lb.

(d) *Use of castor oil in nylon.* The nylon is of the 6-10 type, and is made by coupling sebacic acid with hexamethylene. It is produced under the name of Rilsan by the Societe Organico in Marseilles, France, to the extent of 3-4 thousand tons of monomer annually.

(*Reg. Res. Lab., Hyderabad*)

5. (a) Castor oil is generally processed in some manner before its consumption as a finished product. These processes include: sulphonation (to Turkey Red oil, used for the dyeing and finishing of fabrics); oxidation (for "blown" oils for the plasticization of lacquer, artificial leather, coated fabrics, oilcloth and similar products) ; dehydration (to dehydrated castor oil, for use in protective coatings) ; hydrogenated castor oil (for use in ointments, cosmetics and polishes); saponification (to soaps) ; and other more complex processes.

Medicinal castor oil forms a minor fraction of total consumption.

Due to improved techniques and equipment, today the production of dehydrated castor oil is by far the largest single use of castor oil. The term dehydrated castor oil denotes a drying oil.

Several patents have been taken to cover improved processes to make dehydrated castor oil, such as:

U. S. Patent 1,892,258 (Dec. 27, 1932), H. Ufer.

U. S. Patent 1,942,778 (Jan. 9. 1934), J. Scheiber.

U. S. Patent 1,979,495 (Nov. 6, 1934), J. Scheiber.

U. S. Patent 2,212,385 (Aug. 20, 1940), J. S. Brod.

U. S. Patent 2,278,425 (April 7, 1942), I. M. Colbeth.

In recent years saponified castor oil has found increasing use as a raw material for chemical synthesis. For example, it is a source of dibasic acids, such as sebacic, suberic, and azelaic, used for condensation polymers of the nylon type, and also of many other chemicals useful as emulsifying, cleansing and flotation agents (Kirk & Othmer. Vol. 3, p. 240-244).

(b) By hydrogenation, castor oil can be hardened to yield a somewhat wax-like fat melting at about 85-87° C. The melting point of carnauba wax is 83-91° C. Carnauba wax is an imported article and its annual import is as follows :

	Quantity (cwt.)	Value (Rs.)
1957	1,676	6,62,468
1958	2,159	8,76,028
1959	2,440	10,05,640

It would be interesting to carry out work on hydrogenation of castor oil under various conditions and study the qualities of products with a view to find out its use as a substitute for carnauba wax or other waxes (Kirk & Othmer, Vol. 3, p. 211)

(National Research Development Corporation of India, New Delhi)

Research work in India on Castor Oil

1. Laxminarayan Institute of Technology, Nagpur

Research on the following lines was carried out on castor oil and castor oil products at the Laxminarayan Institute of Technology, Nagpur University :

(a) Sulphation of castor oil and its fatty acids was carried out. The extent of hydrolysis, and the degree of addition of sulphuric acid to the double bond and to the hydroxy group was determined.

(b) Ricinoleic acid of 99% purity was obtained by the urea fractionation method.

(c) During hydrogenation of castor oil fatty acids by hydrazine hydrate, it was found that only the ethylenic linkage was reduced leaving the hydroxy group untouched.

(d) Pyrolytic cracking of castor oil at a temperature of 350° C was carried out in an electrically-heated column.

(e) Work on pyrolytic cracking and preparation of perfumery products is planned for the future.

2. Department of Chemistry, Fergusson College, Poona

(a) Dehydration of castor oil, carried out using various sulphonic acids, showed that increase in the number of acidic groups in the catalyst increases the rate of dehydration of the castor oil and also allows the dehydration to be carried out at a lower temperature. Phosphoric acid, phenol-substituted sulphonic acids, dimethyl and diethyl sulphates, and chlorides of sulphonic acids gave pale-coloured DCO.

(b) In addition to the various factors that have been so far suggested for the after-tack of DCO, a few more factors are suggested. The formation of an intermediate ester with the catalyst, and the effect of a particular catalyst in promoting inter-molecular or intra-molecular polymerization, are also factors controlling the after-tack of DCO. Solvent-segregation of DCO using solvents like isoproply alcohol was carried out. The first two fractions have superior

drying properties, and the third fraction is non-drying. This work supports Lilley and Carter's theory of after-tack of DCO. Anthraquinone and iodine were used as isomerisation catalysts for DCO. The catalyst used for dehydration affects the subsequent isomerisation reaction which has been found to be a reversible reaction.

3. Regional Research Laboratory, Hyderabad

(a) Laboratory and pilot-plant work were carried out on the dehydration of castor oil using sodium bisulphate as catalyst. Using only sodium bisulphate, dark-coloured, high-acid value DCO with heavy after-tack is obtained. By the use of sodium bisulphite along with the catalyst and by treatment of the oil after dehydrition with alkaline substances, DCO of light colour, low acid value and very little after-tack was obtained. The DCO dries in less than 3 hours.

The production of a low-viscosity monomeric DCO has also been carried out. By the use of suitable modifying agents and inhibitors, it was found possible to inhibit the polymerisation of the DCO during dehydration, so that monomeric DCO of viscosity 1.25-1.5 poises (30° C) was obtained. This was found to dry in 2-2.5 hrs. and to be practically free of after-tack.

Use of these DCOs in varnishes, paints and synthetic resins has shown that the use of monomeric DCO confers specially superior properties to the end-products.

(b) *Modification of DCO by styrenation.* DCO can be modified with an optimum of 35 - 60 per cent of styrene in 3 - 6 hours at 180 - 260° C using as catalyst 3 - 6 per cent of benzoyl peroxide depending on the weight of styrene. The use of moderating solvents, such as turpentine fractions rich in pinenes, is only necessary when high levels of styrene are employed.

The films of the copolymers dry hard rapidly and show good water, alkali and acid resistance.

(c) *Hydrogenation of castor oil.* Appropriate conditions have been worked out for the hydrogenation of castor oil so that the maximum of 12-hydroxystearic acid is obtained. The use of alcohol solvent during the hydrogenation does not appear to contribute much useful purpose.

The fatty acids of hydrogenated castor oil, or preferably 12 - hydroxystearic acid, are of great interest to grease manufacturers for the production of multipurpose greases. They are also useful in the manufacture of alkyd resins for plasticising urea-and melamine-formaldehyde resins, and as esters for the cosmetic industry.

(d) *Triricinolein and ricinoleic acid from castor oil.* A good quality of castor oil consists of about 70% of triricinolein (glycerides containing all three ricinoleic groups) and 30% of diricinoleins (glycerides with two ricinoleic groups plus one other fatty acid like oleic, linoleic or saturated). By extracting castor oil with petrol ether 40° - 60°C, or with hexane, these diricinoleins can be removed as the soluble fractions, leaving behind the triricinoleins in 60-70% yield. This can be done by batch or continuous extraction. The triricinolein obtained contains 98 - 99% ricinoleic acid, and has a higher acetyl value (160) and viscosity (6.3 poises) and a lower I. V. (80) than castor oil.

From such triricinolein, ricinoleic acid of good quality can be prepared by saponification and acidification. The small amount of dihydroxystearic acid present precipitates to the bottom on keeping overnight.

From castor oil fatty acids, ricinoleic acid can also be obtained by urea adduction. Saturated and oleic acids are first removed as a urea adduct precipitate, leaving in solution ricinoleic acid containing linoleic acid. A second adduction will now give, as urea adduct precipitate, 50% of ricinoleic acid of high purity.

(e) *Utilisation of hydroxy compounds.* Systematic work is in progress on the utilisation of various hydroxy products derived from castor oil. These hydroxy products are prepared using hydrogen peroxide (now made in Bombay) and glacial acetic acid or acetic anhydride. The trihydroxy fatty acids, triglycerides and alcohols made from castor oil have been tested in ester and alkyd-type surface coatings. The glycerides gave a particularly good alkyd product. Utilisation of these hydroxy materials by oxidation, dehydration and sulphation is under study. Short-chain hydroxy products made from castor oil derivatives are also under study on similiar lines.

(f) *Castor fatty alcohol as an excellent wetting agent.* The fatty alcohol derived from castor oil is an excellent wetting agent, about 1.5 times as effective as lauryl sulphate. It is as good a detergent as the latter and has similar powers of emulsification. Its foaming, suspending and surface tension-lowering powers are less than that of lauryl sulphate. Particularly because of its exceptional wetting power the product should have value as a surfactant base.

Castor oil was converted to the corresponding alcohols for this study by the sodium reduction method, which is not yet industrially feasible in this country. The other method of preparation of fatty alcohols, *viz.* by using hydrogen under high pressure, is under study in the Laboratory. This is potentially feasible in India.

(g) *Arylalkyl products from castor and other oils.* The alkyl chains used for coupling to an aryl nucleus in order to produce detergent bases

are usually about 12 carbon atoms in chain length. Alkyl chains of similar chain length which may be obtained from vegetable oils include undecylenic acid and alcohol, monobasic acids, dibasic acid half-esters and fatty alcohols. These are being converted to acyl chlorides and coupled with suitable benzene derivatives to give neutral compounds, which may be sulfonated to surfactant products. A series of such compounds are being prepared for testing. One advantage of the straight alkyl chain of these products derived from fats, as compared to the branched alkyl chain of the usual petroleum-based products, is that the former are biologically oxidised and do not build up foam when discharged into sewage for disposal.

(h) *Glycerides containing ricinoleic acid.* Tri-, di-, and mono-ricinoleins, prepared either by synthesis (to obtain pure products) and by glycerolysis (to obtain mixtures with a high proportion of one product), are being evaluated for their surface-active properties. Since all the three products contain a total of 3 hydrophilic groups, situated either on the long chain or in the glycerol moiety, the comparative surfactant properties should be of great interest.

(i) *Castor-modified alkyd resins*

(i) *Straight alkyd resins.* Non-drying short-oil alkyd resins of excellent transparency and colour were obtained using castor oil at 220-230°C, while drying-type resins were formed at 270-280°C probably by dehydration of the oil *in situ* at the higher temperature. Resins obtained at 270°C gave tack-free films in less than 30 minutes., while those obtained at the lower temperature had residual tackiness. Baked castor oil alkyds possessed high gloss, good flexibility, excellent adhesion, high scratch hardness and resistance to water, acids and alkalis. Work is in progress to prepare drying-type castor alkyds of 66 per cent oil-length using sodium bisulphate as the dehydrating agent *in situ*; at 205°C dark products were obtained, but at 150°C pale-coloured products resulted.

(ii) *DCO alkyds* via *the monoglyceride.* Short-oil DCO-glycerol alkyds prepared by the monoglyceride method gave a heavy wrinkle finish on stoving at 120°C for 30 minutes. Pentacrythritol alkyds dried faster than those from glycerol. Monomeric DCO alkyds, unlike those from ordinary (higher viscosity) DCO, were decidedly tack-free. Alkyds of high viscosities and low acid values were obtained using monomeric DCO without any risk of gelation.

(iii) *Exposure tests.* Exposure tests indicate that white pigmented paints incorporating titanium dioxide and zinc oxide prepared from castor resins made *in situ* discoloured due to rusting from the metal base, while those from straight castor remained

intact. Paints prepared from monomeric DCO are comparable to those prepared from straight castor oil. Using either lithophone, or lithophone with zinc oxide, no failure of the paints was observed either from castor oil or from monomeric DCO.

4. Shri Ram Institute for Industrial Research, Delhi

(a) *Dimer acids.* Pure linoleic acid or an acid mixture rich in linoleic and linolenic acids, such as those derived from linseed and safflower oils, have been polymerised to dilinoleic acid in the presence of a catalyst capable of producing free radicals, *e.g.* benzoyl peroxide. This type of polymerisation is called addition polymerisation. In the cases just mentioned, saturated or oleic acid monomers have to be removed by distillation to obtain the dilinoleic acid. If ricinoleic acid derived from castor oil is heated at high pressure with the catalyst in the presence of moisture, it first dehydrates, and the linoleic acids thus formed then dimerise to give 90-95% dilinoleic acids, and there is no problem of removing monomers. The process is covered by Indian Patent 70,174 (1959).

Very encouraging results have been obtained in synthesising polyamide resins from these dilinoleic acids. Other known uses are in surface coatings, where they can replace both oils and phthalic anhydride; in synthesis of resins like polyesters, polyurethanes, etc; and by condensation with glycols to give excellent lubricating oils and mould-releasing compounds.

(b) *Alkyl - Aryl syndet from castor oil fatty acids.* Demand for synthetic detergents is steadily growing all over the world, and a beginning has already been made for their commercial manufacture in India. However, of all the syndets available, those based on dodecyl benzene command the highest sale. Since this particular raw material is a product of the petrochemical industry, its indigenous production is not expected to materialise in the near future. Consequently an attempt was made to synthesise from castor oil fatty acids a syndet having close structural resemblance to dodecyl benzene sulphonic acid.

Using sulphuric acid as a condensing agent, the hydroxyl group of ricinoleic acid was replaced by an aryl group, and the product was later esterified and sulphonated. The compound thus obtained was quite soluble in water, showed good dispersing and surface-active characteristics. However, after compounding with the usual 'builders' it showed poor surfactant properties in comparison to a market product. The likely causes for this shortcoming may be the action of oleum on the double bond, incorrect builder formulation, or poor intermediate purification.

5. National Chemical Laboratory, Poona

(a) Castor oil is the starting material for the production of undecylenic acid, heptaldehyde and octanol-2. These materials are used for

the production of valuable perfumes. In the Organic Chemistry Division of the National Chemical Laboratory, processes have been developed for the preparation of undecylenic acid, heptaldehyde and octanol-2 and in the Essential Oils Division, octanol-2 has been utilised for the preparation of dihydrojasmone and undecylenic acid for the dihydroisojasmone and *r*- nonalactone. The process for the preparation of dihydrojasmone has been patented and pilot-plant experiments are nearing completion. The economics of production will be worked out after completion of pilot-plant trials. It is difficult to assess the actual quantity of these materials consumed in India.

6. Department of Chemical Technology, University of Bombay

(a) *Dehydration of castor oil using sulphuric acid at low pressure.* Low-pressure dehydration with sulphuric acid as the catalyst yields a product pale in colour, quick in drying and low in acid value. The optimum conditions are 0.15 to 0.30% sulphuric acid, pressure of 10 mm. of mercury and a temperature of 250° C.

(b) *Miscibility of castor oil with some petroleum products.* Low-boiling petroleum hydrocarbons, kerosene, white oils and lubricating oils have been found to be miscible with castor oil at room temperature in high as well as in very low concentrations of the castor oil. In the intermediate region, the extent of miscibility of the two depends upon the Aniline Point of the petroleum product.

(c) *Estimation of dihydroxystearic acid in castor oil.* The oil is hydrogenated under conditions which will not cause dehydroxylation. The hydrogenated product is converted to methyl esters and the dihydroxystearic acid is estimated by using periodic acid.

(d) *High-pressure hydrogenolysis of castor oil.* Using cobalt-stabilized copper chromite (5%), temperature of 325° C and pressure of 2500 p. s. i. g., castor oil was converted into corresponding fatty alcohols to the extent of 72%. There was some dehydroxylation of the secondary hydroxyl group of the ricinoleic acid chain.

(e) *Fatty acid composition of castor oil.* By means of a new technique, the methyl esters of castor oil are separated into hydroxy and non-hydroxy portions. These are then analysed for I. V., absorption in the ultraviolet region, etc. from which the fatty acid composition is calculated.

(f) *Hydrogenation of castor oil.* Using Raney nickel and dry-reduced nickel catalyst, castor oil was hydrogenated at different temperatures in the range of 80-240° C. The extent of various reactions like saturation, dehydroxylation, and dehydration has been studied.

(g) *Hydrogenation of castor oil in solvent media.* The effect of temperature, pressure, catalyst concentration (Raney nickel) and dilution on the course of hydrogenation of castor oil in presence of ethanol as a medium has been studied.

(h) Use of castor oil derivatives as plasticizers for polyvinyl chloride in fabric coatings.

(i) *Utilization of castor seed cake.* Condition for the extraction of castor seed proteins from defatted cake have been standardized. The proteins obtained are suitable for the preparation of distempers, oil-bound water paints, etc.

(j) *Preparation of dehydrated castor oil fatty acids.* Work is in progress on the Kinetics of the formation of estolides and their subsequent decomposition.

7. Department of Applied Chemistry, University of Calcutta

Potassium permanganate oxidation of a dilute solution of saponified castor oil containing slight alkali excess gave a 24.6% yield of crude and 17.6% yield of pure azelaic acid, the cost of the latter working out at Rs. 20.65 nP. per lb. Nitric acid oxidation of ricinoleic acid gave 4% of sebacic acid and 7% of azelaic acid on the weight of castor oil, the cost of mixed acids working out at Rs. 8.49 nP. per lb. The di- and monoethyl esters of azelaic acid were prepared as a first stage in the study of such materials.

DISCUSSIONS

J. G. Kane: I am indeed very happy to be amongst you to join in the discussion on castor oil, which is a subject of vital importance. As I see it, the gathering is made up of practical men from the industry, workers in research laboratories and teachers from the universities. There are veterans and there are aspirants who are full of new ideas and there are persons like me who bring up the rear. Whatever our position and whatever our contribution to the subject under discussion, today's seminar is directed towards a collective and co-ordinated effort to solve our problems—one after another, big or small. The importance of castor oil in the economy of this country and the advantages to be gained by its increased utilization and exploitation are obvious to a gathering like ours, and have been stressed in the speeches this morning by Dr. Zaheer and Shri Pattabhirama Rao.

The notes received in reply to the questionnaires sent out earlier have given us a good deal of information on these topics, enough at any rate to serve as a starting point for discussion here. This information may be supplemented here if need be. I would also like to draw your attention to the excellent chapter on the "Chemistry and Technology of Castor Oil" contributed by K. T. Achaya, M. A. Sivasamban and S. Neelakant Rao in the

monograph on Castor written by Dr. L. G. Kulkarni and published by the Indian Central Oilseeds Committee. This would also serve as a good background for today's discussion.

The subject matter for discussion in this first session under Section A: Castor oil, deals broadly with (1) present-day uses of castor oil in India, (2) present-day uses of the oil in the U. S. A., (3) research work already done in India on castor oil, (4) research work being done currently, and (5) possibilities for new processes and new products based on known information or on the research work currently being carried out.

I shall now deal briefly with these. We may first consider the general categories of uses of castor oil irrespective of any particular country, and then consider the current uses in this country. The uses of castor oil can be classified into four categories: (a) those in which the oil is used as such with or without refining; (b) those in which the unrefined or refined oil is mixed with other ingredients; (c) those in which there is chemical transformation of the oil not involving a profound change; and lastly, (d) those in which there is chemical transformation of oil accompanied by a drastic change.

It will be seen that out of these four categories, castor oil is being used in this country for such uses as fall in the first three categories. If a greater utilization of the oil is to be aimed at, greater emphasis has to be given to uses in the fourth category. This naturally will depend on what applied research work is being carried out in the various laboratories in this country, and the attitude of industry. Sometimes industrialists are not satisfied with research work; it is therefore for them to specify the nature of and priorities for the research work they need. Even processes brought up to the pilot-plant level are not utilised by Indian industry. Any difficulties experienced might be discussed here so that research work may be smoothly transferred to industry. We may now go into the questions one by one.

Q. 1: What are the present uses of castor oil in India, percentage-wise and tonnage-wise? Could any of these be stepped up by making improved products?

Q. 2: What is the tonnage of dehydrated castor oil in India? What are the uses to which it has been put? What is the tonnage used in the paint industry vis-a-vis *other drying oils?*

Q. 3: What are the reasons for dehydrated castor oil not enjoying greater popularity than at present?

a) Dehydrated Castor Oil (DCO)

K. T. Achaya: The actual figures given for the various uses of castor oil in India are probably not very accurate since they do not tally with the amounts shown (Hindustan Lever estimates under Section C), to be available in the country. It would appear that some 5000 tons of castor oil are used in the country.

It would be of great interest to know why DCO is used in a crude form in the country and why the improved types of DCO produced *e.g.* in our own laboratory, are not being more readily exploited by the industry ?

N. G. Chatterji: The improved DCO produced by the Regional Research Laboratory, Hyderabad, was sent by me to a firm in Australia but nothing has been heard from them since. Enquiries from foreign parties do come in from time to time. Firms in Commonwealth countries perhaps prefer to get their processes from the parent company usually in England, unless an Indian process offers a large economic advantage.

The patents and published papers do not give sufficient details to enable improved DCO to be prepared and sent to leading manufacturers in India for actual tests by the paint industry.

Both light colour and quick drying are necessary in a DCO to give, *e.g.* a good alkyd product. A good product was obtained using iodine, but the colour was poor. Best results were obtained using diethyl sulphate but the colour was still not quite as satisfactory as desired.

Economic factors such as price, proximity of supply, etc. may also play an important part in the development of DCO.

J. G. Kane: Two points appear to have arisen so far:

a) If the product produced as a result of laboratory research is really good, why is there not an increased internal consumption of DCO in India? Are the prices of DCO based on production method very different in India and abroad? Are any figures available? Do factors like patenting and lack of complete economic data come in the way of exploitation of the product?

b) Even sulphuric acid is reported to be used for dehydration in Indian industry. If so, the colour of the product is bound to be poor and if such a product is still being used, colour does not appear to be a factor of great importance. There is some conflict of views here.

J. S. Aggarwal: In the Regional Research Laboratory process, at first a mixture of sodium bisulphate and sodium bisulphite was used, but later zinc dust was also added as polymerisation retardant. The use of sodium bisulphate alone gives a dark colour but when sodium bisulphite is added and vacuum employed, the colour is extremely good. The product is certainly of good quality; high vacuum is very essential and perhaps this is one of the difficulties felt in its adoption by industry. The process has been taken by a firm in Bombay but not exploited so far. The product is being repeatedly prepared on a pilot-plant scale for our own laboratory studies. In our experience, while there is usually no after-tack in the product, an occasional batch will yield an after-tack on drying. The colour continues to darken as the product is stored. Additives have been tried without success so far.

Of course, linseed oil also darkens on storage but not to the same degree. Tung oil is superior in respect of colour stability, though, of course, it would not be proper to compare DCO with tung oil. DCO stands, as it were, between tung oil and linseed oil.

K. S. Chari: The impression created in the discussion today is that the RRL process for making an improved DCO is not being adopted because vacuum is involved. But the production of vacuum should not scare away industrialists since it is quite a simple matter practised in industry. The pre-costing of DCO was based on extensive work using a dehydration unit of capacity 7.5 gallons. Full information regarding the costing and other data is available to anyone from the National Research Development Corporation of India which handles all patented processes developed in CSIR laboratories.

K. R. Varma: Almost all large oil industries use upto 29 inches of vacuum, which is not difficult to obtain. Small industries may perhaps have difficulty in using any process based on vacuum.

M. A. Sivasamban: There appears to be a lack of free exchange of information between the industry and research laboratories. We have gone round various factories and requested them to let us know their difficulties but have not had very much in the way of response. One-gallon samples of DCO were sent round to a very large number of factories and the test results reported are quite satisfactory, but even so the product has not been exploited. The costs worked out by us have been published in *Paintindia* and by the NRDC ; these show that the cost of dehydration is about 17 nP per lb. and the cost of DCO Re. 1.06 nP per lb. (loose). Even in the U.S.A., DCO is slightly costlier than linseed oil. The reason for lack of production by the Bombay firm which has licensed our patent may perhaps be due to lack of machinery caused by import difficulties.

K. K. Dole: Paint technologists in the country probably prefer to use cheaper linseed oil in preference to any other product, including DCO of superior quality. We have published our work showing that very good dehydration, and products of good colour, are obtained using either phosphoric acid or a monophenol (especially *ortho*) sulphonic acid. Being a college laboratory, we work only on a laboratory scale, and would like manufacturers to contact us to try out our catalysts on a large scale. In regard to after-tack, recent work shows that any catalyst present as a soluble material in the oil, leads to intramolecular polymerisation without increase in molecular weight, *i.e.* between double bonds in the same molecule ; this type of polymerisation results in after-tack. Considerably less after-tack is obtained if the polymerisation is intermolecular, and the catalyst should be chosen accordingly.

N. G. Chatterji: The main obstacle is the reluctance of industrialists to invest in a product which does not give quick returns. Many years ago, I hit on a method of producing a good DCO product, using sodium bisulphate, sodium bisulphite and aluminium. A capacity of 50 gallons would have been necessary, but the financiers were unwilling to invest the necessary capital of 40-50 thousand rupees and so, the scheme was dropped. European-owned

factories in India get their processes mostly from abroad and are not, therefore, much interested in Indian-developed processes. They have alkyd plants which could be used with practically no modification for making DCO also. It is also reported that they are able to make DCO and an alkyd product simultaneously.

N. Bhojraj Naidu: To reduce the price of DCO, it would be worthwhile to think on the lines of using unrefined and unbleached castor oil which is much cheaper than refined castor oil. Though it has been stressed that the price difference is marginal between linseed oil and DCO, we tend to forget the distinctive properties of a DCO compared to a linseed oil product, *e.g.* superior resistance to water and alkali, though the film is less tough. It has also been noticed that in cooking an alkyd, a distinct reduction in colour occurs in the glycerolysis stage and the final product is much lighter than can be envisaged from the colour of the starting oil. Moreover, straight castor oil alkyds are as good as DCO alkyds if properly prepared. I would also like to stress what Dr. Chatterji has remarked, *viz.* that the DCO can be made *in situ* during the resinification stage of alkyd preparation, though a slightly darker alkyd results.

J. S. Aggarwal: I agree with Dr. Naidu that *in situ* reactions are always preferred if they can be fitted into a process.

We would be glad to try Dr. Dole's process on a pilot-plant scale if full details of the laboratory experiments are furnished to us. His technique of continuous dehydration can also be enlarged.

R. K. Kochhar: Improvements in products based on DCO can also be sought by adding say 10% of dimer acids. Resulting films are hard but flexible, with good alkali and water resistance.

J. G. Kane: To summarise, it appears that though DCO may not compare with tung oil, it ought to have a place in the paint industry. An interesting point has been made regarding preparation of DCO *in situ*. It would appear that large factories in India are not much interested, and smaller industries are not willing to invest. There is always resistance to a new product and the only way would be to make large samples available freely to various industries for formulation. Meantime, the results of exploitation of the RRL process by the Bombay firm to whom it has been leased will be awaited with interest.

(b) Turkey Red Oil (TRO)

V. B. Chipalkatti: TRO, though out-of-date, continues to be used to some extent in the textile industry. Its defects are instability to calcium and magnesium salts and under conditions where metallic contamination is present such as in the *pasting* of dyes, and in finishing and sizing. Moreover, TRO is produced from a costly raw material, *viz.* castor oil, and cannot compete with dodecyl benzene sulphonate which is much cheaper, being a petroleum-based product.

N. G. Chatterji : I agree with Dr. Chipalkatti that the product is outdated ; nevertheless a demand still exists, and one factory in the U. P. alone sells about 5 to 10 tons every week.

J. G. Kane : While TRO appears to have had its day, we must still bear in mind that it would not always be wise to substitute an indigenous material with an imported material even if the latter has certain advantages. Will it be possible to use castor oil in any other ways to obtain wetting agents ? For example, the sulphonated castor esters are extremely good wetting agents, even though a little expensive.

K. T. Achaya: I should like to draw attention to some recent work in our laboratory on the exceptional wetting powers of ricinoleyl alcohol, which is the fatty alcohol produced from castor oil. The sulphate salt is about 150% as powerful a wetting agent as lauryl alcohol sulphate. This work is shortly to be published in the *Journal of Chemical and Engineering Data*. The material was produced for laboratory purposes by sodium reduction, which is not yet industrially feasible in India. We are, therefore, trying to make it by high-pressure hydrogenolysis though there is the difficulty of retaining the double bond and the hydroxyl groups under drastic conditions.

R. K. Kochhar: At the Shri Ram Institute for Industrial Research, we have obtained castor monoglycerides in high yield from castor oil by glycerolysis. These contain three hydroxyl groups which can be sulphated. The products should have good surfactant properties and these are being tested.

V. B. Chipalkatti: It is worth reflecting that wetting agents are often used blindly in many products even though they are not really required. For example, kier boiling is carried out over 8 hrs. and it is difficult to see why a surfactant is at all necessary. To give another example, at one time wetting agents were used to disperse dyes in solution for printing. Today, however, dyestuffs are available ground so fine that the use of good quality soft water is sufficient to ensure adequate dispersion. Similarly also the use of TRO as a softener in the size mixture is not really necessary. The textile industry as it exists today is a mixture of a great deal of craft combined with a little science. It is necessary to change this situation and introduce a good deal of science and scientific thinking in the day-to-day working. Of course, I do not mean by this that work on surfactant products from castor oil should not continue. Products of higher degrees of sulphonation should be investigated.

K. S. Murti : The cheapest oils available today, such as tobacco seed, neem and rice bran, cost about Rs. 1000 a ton. The sulphonated products derived from tobacco seed and rice bran oils were tested in our Institute against TRO and found to be as good as, and sometimes even better than, the latter. They were then prepared on a pilot-plant scale and sent to various Institutes for testing. Neem and cottonseed oils need preliminary treatment but thereafter give better products. If castor oil cannot be used because of its high cost, these cheaper oils are worth consideration.

(c) Lubricant Use

J. S. Aggarwal: The very name lubricant suggests a vegetable oil component ; mineral oils need an additive to impart lubricity. Because of its high viscosity and low freezing point, 5 to 10% of castor oil is added to many lubricants. After hydrogenation, castor oil finds use as lithium-based greases for roller bearings.

V. Samuel: I would like to point out that castor oil is not essential in a lubricant though it has certain virtues. One product made from castor oil, *viz.* sebacic acid in the form of an ester, possesses a very high viscosity index and is used in jet engines. 12-hydroxystearic acid is also extremely useful for making lithium-based greases. STANVAC has a scheme of manufacturing high-temperature greases in India, and 12-hydroxystearic acid could be processed if available.

Blown castor oil, which is miscible with mineral oil unlike castor oil itself, is also of interest. No one in India has yet made a satisfactory product.

N. G. Chatterji: One of the best clients for castor oil is STANVAC, who buy it in terms of thousands of tons and to rigid standards, though we do not know to what use it is put.

V. Samuel : It is not necessarily used only in lubricants.

J. S. Aggarwal: STANVAC has recently written to us for 100 lb. of hydrogenated castor oil and we are working to produce the material on a pilot plant. Generally speaking, the price of this material should not be very different from that of stearic acid.

J. G. Kane: Those interested might obtain the requirements for blown castor oil laid down by STANVAC. I might point out, however, that the miscibility of castor oil in mineral oil is not as low as is commonly believed. At room temperature, castor oil dissolves nearly 20% of lubricating oil, and lubricating oil in turn dissolves only 5% of castor oil. Usually 5-10% of castor oil in a mineral oil imparts sufficient lubricity.

(d) Castor Oil as a Tallow Substitute

J. G. Kane : It may be mentioned that castor oil as such may be used in place of tallow for sizing. Even more suitable would be semi-hardened castor oil. Of course, the only factor against this use is the higher price of castor oil (about Rs. 1600 per ton) compared to imported tallows (Rs. 1200 per ton).

Q. 4 : What are the present uses of castor oil in the U.S.A. ?

Q. 5 : Can any of these newer uses be started immediately in India ? Do we have enough technical know-how ? What is the demand for products under these new outlets in India and abroad ?

J. G. Kane : The printed information supplied in advance gives fairly detailed data on the uses of castor oil in the U. S. A. I would like to ask if there is any information on any use in other countries than the U. S. A.

K. T. Achaya: The only big use apart from those listed is perhaps the use of castor oil in the preparation of undecylenic acid and thence of nylon in France to the extent of 3-4,000 tons annually. This appears to be the only major new use of castor oil in a country other than the U.S.A.

K. K. Dole : They are trying to modify the nylon produced in France so as to give it greater elasticity. This is a new development in this field.

V. Samuel : Sulphurised castor oil is another product from fats which is used as a factice in the plasticizers employed in the rubber industry.

J. G. Kane : We shall now turn to the possibility of starting in India some of these new uses of castor oil, either those current in the U. S. A. or elsewhere abroad (which are mostly breakdown processes), or others which are entirely new and are being developed in this country itself.

(a) Perfumes

J. S. Aggarwal : In the absence of a representative, I would only like to draw attention to the work of the National Chemical Laboratory, Poona, on the preparation of perfumes from heptaldehyde and undecylenic acid ; a note in this regard has been included in the printed data.

(b) Urethane Foams

K. T. Achaya : There is little to add to what has been summarised in the printed data. This information has been drawn from two recent papers in the *Journal of American Oil Chemists' Society* (1959, *36*, 16 and 541) and one in *Chemical and Engineering News* [1959, *85* (22), 51.] These foams are made by reacting isocyanates, which are made in America by two companies, with oxygen-containing compounds, especially ethers. In place of ethers, castor oil can be used and gives rise to a flexible type of foam. The competitor for these urethane foams is the rubber type of foam, but it would appear that rubber foams are much more expensive than urethane foams.

J. S. Aggarwal : I would like to point out two possible drawbacks : firstly, one reaction component, the isocyanate, is not available in India, and secondly, it is also a rather poisonous material.

T. S. Ramaswamy : In the final urethane foam, 80% can be castor oil and only 20% the imported isocyanate product. In case of rubber foams, on the other hand, we have to import the entire raw material.

(c) Sebacic Acid and Undecylenic Acid

J. G. Kane : Sebacic acid has other uses than in jet engine lubrication and these should also be considered. The manufacture of sebacic acid could be looked into.

J. S. Aggarwal : Sebacic acid is made by fusion of the soap of castor oil in the presence of a very large excess of alkali. This work has been carried up to the pilot-plant stage at the National Chemical Laboratory, Poona. The other product, 2-octanol, can be used as a plasticizer.

R. K. Kochhar : Sebacic acid is also employed for the preparation of polyesters. If to a mixture of sebacic acid, phthalic anhydride and glycerol, styrene is added and the product cured, very hard materials are obtained which have good adhesion and a very high electrical resistance. They can be used for lining vessels such as food containers, and for casting at a low temperature.

J. G. Kane : I would like to call for figures about consumption in India of dioctyl sebacate as a jet engine lubricant. I would also like the economics of production in India and perhaps of export to be considered.

V. Samuel : At present all lubricants are being imported into India. We are not sure of the composition of these imported products. Unless the economics of a process are known, it is difficult to say anything about selling the product either in this country or abroad. As an example, soaps of very high quality are produced in this country but we are still unable to export them to any great extent.

K. R. Varma : Two types of nylons are based on castor oil products. Sebacic acid is used to make 6-10 nylon. Undecylenic acid is used to prepare the type of nylon product known in France as Rilsan. The other product of castor oil cracking, *viz.* heptaldehyde, goes into perfumery. The economics of this process seem to depend almost entirely on the yields of and outlets for undecylenic acid. Work is in progress at the Research Department of Tata Oil Mills, Bombay.

K. T. Achaya : The difficulty in obtaining a high yield of undecylenic acid is that whenever it is fractionally distilled for purification, considerable polymerisation occurs, thus reducing the yield. We attempted to crystallise it and obtain crystallisation from 80% methanol, but the crystals are fluffy and gelatinous and cannot be filtered at all. Perhaps centrifugation might help.

It also occurs to me that the two products of alkali fusion of castor oil, *viz.* secondary octanol and sebacic acid, can again be re-esterified to give a dioctyl sebacate which may also perhaps function as an aero-engine lubricant.

Q. 6 : *Are there any other known fields, such as those mentioned below, in which the use of castor oil can be investigated, where an Indian-made product would undersell a foreign?*

(a) Perfumes (Type, Quantity Used, Economics of Production)

T. S. Ramaswamy : Our total requirement of heptaldehyde in the country appears to be 5-10 tons annually. But there is as yet no capacity in the

country itself. Heptaldehyde can be condensed with benzaldehyde to give cinnamic aldehyde, which is being produced in India by two firms, Industrial Products (Limited) and Kelkar, both of Bombay. The other product, undecylenic acid, constitutes a disposal problem since it accumulates to the extent of 100 tons per year. Research on utilisation of this material should be intensified. The cost at present is about Rs. 10 per lb. and hence utilisation in medicine or nylon type of products will be preferred outlets.

K. T. Achaya : We are working on coupling undecylenic acid with benzene by a Friedel-Crafts reaction when alkyl aryl bases are obtained which can be sulphonated and neutralised to surfactant products. Large quantities of froth are produced by the use of alkyl aryl products because they are not biologically consumed. Recently, this has been shown to be a result of the branched alkyl chain in the product. If a straight chain is present, no foaming occurs. Products from undecylenic acid will have a straight chain.

(b) Lubricants (Types Using Castor Oil, Quantities Used, Costs)

J. G. Kane : We have covered this ground fairly fully earlier, and so shall pass on to the next topic.

(c) Detergents (TRO, Quantities Used in India and Abroad, Prices)

J. G. Kane : Is there an export market for TRO ?

T. S. Ramaswamy : We have looked into this. The main difficulty is the import duty levied in other countries. For castor oil, excise duty is only 5% but for TRO it is 20-25 %.

R. K. Kochhar: TRO is one surfactant product from castor oil and another (castor monoglycerides) has already been mentioned. A third can be produced from ricinoleic acid. The hydroxyl group is coupled with benzene in the presence of 80% sulphuric acid. The acid group is now esterified and the product sulphonated. The product was mixed with builders and tested, but the surfactant properties were not very good. Perhaps this may be due to the builders used, or to the rather long aliphatic chains. Further work could perhaps be done.

K. T. Achaya : I would suggest esterification of castor oil by interesterification with an alcohol before rather than after the coupling stage.

(d) Foams (Types, Basis of Use of Castor Oil, Work Being Done Abroad)

J. G. Kane: I do not think there is anything more to discuss in regard to foams than what has been said this morning.

(e) Hydrogenated Castor Oil (Use in Lubricant Greases, as a Dispersing Agent in Paints, and Other Uses)

J. S. Aggarwal : 0.5 to 1% of this product is used as a dispersing agent for pigments in paints. It would not contribute in any way to increase in viscosity.

J. G. Kane : Castor oil products hydrogenated to intermediate degrees are sometimes vaseline-like. At higher degrees, the products are hard. We might consider whether the intermediate products when saponified could be used as greases.

V. Samuel : A product consisting of castor oil dispersed in the sodium soap of hydrogenated castor oil is used as a grease in certain types of vacuum pumps.

M. Narayana Rao : Hydrogenated castor oil can also be used in the form of an emulsion for preservation of fruits and vegetables.

H. A. B. Parpia : I would like to say a few words on the technique developed at the CFTRI, Mysore for preparation of fungicidal wax emulsions for coating of fruits and vegetables to increase their storage life without refrigeration. Carnauba wax and sugarcane wax have been used successfully for the purpose. One of the major requirements of the wax to be used is that it should have a melting point of 80 to 85°C. It may, therefore, be advisable to consider the possibility of using hydrogenated castor oil for the purpose provided that it has no harmful effects on the consumer. Therefore, it may be advisable to consult the CFTRI in this connection and collaborate with them for the work.

J. G. Kane : Does hydrogenated castor oil retain the purgative properties of castor oil ? Also, is not paraffin wax equally suitable ?

R. K. Kochhar : Paraffin wax will not be absorbed by the body. In the U.S.A. aceto-glycerides are being used for this purpose. Some work is being done at the Shri Ram Institute for Industrial Research on preparation of such materials.

K. K. Dole : I would suggest the use of rice wax, a by-product of the rice bran oil industry which is fast developing in India. There are two waxes, of melting points 63°C and 74°C respectively, and the latter might be suitable.

K. Krishnamurthy : Rice wax has been tried among other products.

V. Samuel : I might point out that wax emulsions are prepared by us for use in the paper industry. The preparation of such wax emulsions is not difficult and any wax finally selected as a result of tests can be emulsified for use in fruit preservation. Such wax emulsions are easily miscible with water.

N. Bhojraj Naidu: Castor oil can be used instead of alcohol in transparent soap formulations.

Q. 7 : What are the items above needing research (laboratory or cost-engineering)? Are they worth doing ? Would industry aid such research financially ?

J. G. Kane : This question boils down to one of evaluation of the research done and the stage to which the research has gone. There is no co-ordinated thinking between fundamental research, industrial research and industria-

lists. Perhaps we can consider some of the difficulties coming in the way of commercial exploitation of any process. This morning DCO has been discussed in this way to some advantage. Perhaps we can now look into hydrogenated castor oil which has been actively pursued at the RRL.

J. S. Aggarwal : Laboratory work is complete and pilot-plant trials are about to begin. This will include costing of the process.

J. G. Kane : I would be interested to know something about the costing of undecylenic acid and heptaldehyde. Let us look into this question of perfume from heptaldehyde. Has the price of cinnamic aldehyde, for instance, been reduced by indigenous manufacture over its former imported price ?

K. R. Varma : Heptaldehyde was formerly imported from France at a cost of Rs. 3-4 per pound. When made in India, the yield of heptaldehyde is only 10-12% of castor oil. The entire cost falls on heptaldehyde, and as things now stand, it would cost Rs. 10 to 12 per lb. On the other hand, if a use could be found for undecylenic acid, this costing will change. In France, heptaldehyde is a by-product while in India it is reverse. Further the type of process used, whether batch or continuous, plays an important part in the recovery of undecylenic acid. Only use in a big industry such as nylon, or as a fungicide like the monoethanolamine salt, can make undecylenic acid available at a lower rate.

J. G. Kane : We can now go on to consider whether the industry would aid such research and whether it is really keen on such research being pursued. Why does it not take up processes developed in the country?

N. G. Chatterji : The tendency is for the Indian industrialist to get plant from outside with all the accompanying know-how and know-why. He gets full assurance that every little detail has been worked out, of which he cannot always be sure in India. He is prepared to pay the extra price rather than having to smooth out any process difficulties. He also depends on the suppliers for information on fresh developments.

V. Samuel : STANVAC is greatly interested in 12-hydroxystearic acid and if there is a proper approach, they might even be prepared to assist the work financially. Of course the company has its own big research laboratory whose primary purpose is to find out local raw material substitutes for products so far imported.

V. B. Chipalkatti : I differ from the view point that Indian industrialists are lacking in enterprise. It would be difficult to find an entrepreneur bolder than the Indian industrialist. I know of industrialists willing to spend large amounts of money to prove the feasibility of a process on a pilot-plant. The main trouble is that research in India is not yet appreciated by the users because (unlike in the developed countries) the value of ideas is not appreciated unless these are backed by experience. When there is no experience available in the country, naturally one has to take enormous pains to prove the worth-whileness of new ideas. I hope that this situation will change as

more and more experience is gathered both at the research level as well as at the industries level. The present trend of building pilot-plants for known products and known processes will gradually be replaced by building pilot-plants only in the case of new products or genuinely new processes.

J. G. Kane : Conditions in India are different from those in more advanced countries. I am sure an Indian worker would be very happy to merely sell an idea, which is after all much easier and does not involve him in pilot-plants and costing, which are really a burden. The Indian businessman has to be convinced with more than merely research data, and hence pilot-plants become necessary.

Q. 8 : What are the present research lines on castor oil in India which are complete, in progress or to be taken up very soon, which may have practical value as an outlet for castor oil within the country ?

J. G. Kane : I will call upon representatives of various Laboratories and Institutions to briefly explain the research work in progress or ready for exploitation, even though these are already available in the notes.

1) Laxminarayan Institute of Technology, Nagpur

J. G. Kane : No one is present from this Institute and the notes may be referred to.

2) Department of Chemistry, Fergusson College, Poona

K. K. Dole : In the dehydration of castor oil, the residual after-tack might have been caused in the early days by incomplete dehydration, or by decomposition products. We have now found other causes. During dehydration, two types of molecules with different rates of drying are formed. In one, the double bond is destroyed intramolecularly, and this results in an after-tack. In the other, double bonds from different molecules react intermolecularly and give rise to good drying products. Catalysts like phosphoric acid remain in the oil and cause intermolecular polymerisation, while benzene sulphonic acid catalysts give rise to intramolecular polymerisation. These results support the Lilley-Carter theory of after-tack. When DCO was solvent-extracted with *iso*-propanol three fractions were obtained — a drying fraction, a monomeric fraction and a non-drying fraction. Other methods are being tried for industrial use in place of solvent extraction.

Another line being pursued is the isomerisation of DCO to increase it conjugation using as catalysts iodine, anthraquinone, etc. There is an optimum catalyst concentration for maximum isomerisation (50% beyond which the isomerisation diminishes showing that the reaction is reversible. The reversibility was established beyond doubt using iodine-containing compounds. Work is continuing.

Another line of work on the development of the hydroxyl group in castor-seed oil during seed maturation had been temporarily deferred, but will soon be resumed.

J. S. Aggarwal : Can dehydration be stopped at the maximum 50% conjugation stage? Loss of conjugation may be due to polymerisation and not to reversibility.

K. K. Dole : We considered this point earlier and established the reversibility using linseed oil fatty acids, in which only 10% polymerisation occurred. Molecular weights were determined by cryoscopic methods, and the low values obtained showed that only slight polymerisation had occurred.

3) Regional Research Laboratory, Hyderabad

M. A. Sivasamban : The work on dehydration of castor oil was originally based on that of Forbes and Neville. Sodium bisulphate was first used, and sodium bisulphite added later to keep down the colour. To keep down the acid value, alkaline materials are added immediately following dehydration. However, after-tack still remained. At this stage, Chatfield announced that monomeric DCO apparently dries tack-free. We, therefore, tried to keep down polymerisation and found that zinc dust did the trick and that the viscosity was only 1.2 poises in laboratory work and 1.5 poises in pilot-plant working. The product conforms to ASTM specifications, only the colour being slightly greater (product colour 3.6Y + 1.1.R, ASTM Specification 3.0Y + 0.5R). Further work on utilisation of DCO in paints and varnishes has shown that monomeric DCO is very reactive when cooked with resins and that paints based on it are greatly superior in exposure tests to those prepared from ordinary DCO or from linseed oil.

K. K. Dole : When sodium bisulphate is used, the active agent is sulphuric acid. Would it not be better to use *ortho*-phosphoric acid which is easily miscible with the oil? Further, after-tack can be counteracted by incorporating resins in the subsequent formulations.

T. S. Ramaswamy : Have any foreign samples been tested alongside the present products?

M. A. Sivasamban : Yes, the only point of difference is the slightly darker colour of our product. After-tack is of the same order.

M. C. Menon : If, as Dr. Dole has said, isomerisation also occurs during the dehydration process, dehydration could be tried in a flash reaction vessel since this will be extremely fast, and not lead to polymerisation.

Styrenation of any conjugated oil is possible and DCO is almost ideal for the purpose. In published studies, styrenations have taken a long time and we have succeeded in finding a much quicker method which has been described briefly in the notes.

N. Bhojraj Naidu : Castor alkyds can be prepared at a low temperature of 200-230°C but these are non-drying. They could be fractionated with alcohol into drying and non-drying fractions. Alkyds prepared at about 270°C, however, give films which dry in 30 minutes. Wrinkle finishes were obtained when short oil castor alkyds were baked at about 120°C for about 30 minutes.

Haziness is a problem in alkyd formulation and is due to calcium phthalate, but can be removed using triphenyl phosphite or phosphoric acid. Pentaerythritol alkyds give even tougher films and in industry mixtures of glycerol and pentaerythritol appear to be used. Straight castor alkyds were as good as DCO alkyds. Addition of sodium bisulphate was tried at 300°F in the resinification stage; water was given off showing that further dehydration had occurred, and the alkyds thus obtained were pale in colour.

Preparation of DCO alkyds *via* monoglycerides is a tricky business and careful control is necessary. Fumes of acrolein were obtained, probably by decomposition of glycerol. This difficulty was overcome by use of an alkaline catalyst. High-acid DCO must, therefore, be cooked only with careful choice of catalyst. Monomeric DCO alkyds, unlike those from ordinary (higher viscosity) DCO, were decidedly tack-free. Alkyds of high viscosities and low acid values were obtained using monomeric DCO without any risk of gelation. This work will be communicated to *Paintindia*.

Good results were obtained when paints prepared from castor *in situ* and monomeric DCO alkyds of long oil length were exposed.

H. Shripathi Rao : We have carried out a large number of experiments at various temperatures, pressures, catalyst concentrations and time to obtain hydrogenated castor oil products, and have tested these comparatively with samples from the United States. The following are some of the figures :

	USA Product 1	USA Product 2	RRL Product
Iodine value	5.8	5.2	3.7
Acetyl value	138.3	139.6	138.9
Acid value	5	5	2.65
M.pt.°C.	83.5	85	84.5

These results were obtained with Raney nickel catalyst. Other catalysts like palladium are being tried. Hydrogenation of triricinolein is also being tried.

J. G. Kane : We have found that using alcohol as solvent at different dilutions, 2% Raney nickel catalyst, temperatures of 70-130°C and pressures of 100-500 p.s.i., the rate of hydrogenation in the presence of solvent for a drop in I. V. from 85 to 5 was only 1-2 hr. whereas it was 6-8 hr. during direct hydrogenation. There was no dehydroxylation. The amount of water present, *i.e.* the dilution of alcohol, has an influence on the rate of reaction which is optimum at about 10% water content in the alcohol. Ethyl alcohol was superior to methyl or propyl alcohols. Solvent therefore plays a notable part in the reaction. Of course, the economics of using solvent are a different thing altogether.

J. S. Aggarwal : In our experiments, using about 95% alcohol and an oil-solvent ratio of 3, the time of hydrogenation for a final I. V. of about 3 was 4.5 hr. compared to 5 hr. for straight oil hydrogenation. Hence the work was not pursued.

K. T. Achaya : Regarding extraction of triricinolein from castor oil, we have found that a good quality of castor oil is necessary to obtain high-quality triricinolein. Castor oil of low hydroxyl value (which is supposed to be a result of the refining process, according to a French paper) gives poor yields of triricinolein. Since the method was published in 1952, we have substituted light petroleum with *n*-hexane freed of aromatics by treatment with sulphuric acid. The costs have not been worked out but this could easily be done if anyone is interested in the process. Ricinoleic acid of good purity can be obtained from such triricinolein.

We have also obtained even purer ricinoleic acid from the mixed fatty acids of triricinolein by urea adduction as described in the notes.

Progress on the other items of work had been described in the notes. I would again draw attention to the remarkable wetting properties of the fatty alcohol from castor oil, which we have also tried to explain on a fundamental basis.

4) Shri Ram Institute for Industrial Research, Delhi

R. K. Kochhar : I would like to describe three items.

(a) Oleic acid will dimerise in presence of benzoyl peroxide and the product is a good drying material. But it is difficult to get oleic acid free from contaminants. Another product for use as a drying additive is obtained by heating fatty acids with boric acid,when two molecules of water and one molecule of carbon dioxide are released, giving quick-drying hydrocarbon products. The third approach is to heat linoleic acid with benzoyl peroxide to give a dimer. Some isomerisation occurs simultaneously and the double bond shifts, while it is also difficult to obtain pure linoleic acid.

If castor oil fatty acids are similarly treated, they simultaneously dehydrate, and dimerise to the extent of 90 to 95%, giving products which are drying oil additives just like the products mentioned above.

(b) Ricinoleic acid and benzene will couple in the presence of 80% sulphuric acid to give a product of hydroxyl value below 10. Higher strengths of sulphuric acid cause sulphation of the hydroxyl group. The coupled compound is then refluxed for 12 hr. with ethanol using 98% sulphuric acid as catalyst, when esterification occurs. The ring is now sulphonated using oleum containing 10% free sulphur trioxide. The neutralised material is highly soluble in water.

(c) Monoglyceride products obtained so far by heating fatty acids with glycerol, or triglycerides with fatty acids, usually contain a maximum of 40-60% monoglycerides. The catalysts used could not be removed because they are water-soluble and very stable emulsions are formed if water is added.

If heated, reversion to the triglyceride occurs. For use as food emulsifiers, catalysts are not allowed in monoglycerides. A process developed by the Shri Ram Institute gives monoglycerides to the extent of 95% and no trace of catalyst remains in the product, which is, therefore, also not reversible on heating.

5) Department of Chemical Technology, University of Bombay, Bombay.

J. G. Kane : Our work on dehydration of castor oil under vacuum was done long ago and is of no interest in the light of subsequent developments. For the miscibility studies of castor oil and petroleum products, the phase rule was used, and the aniline point of the petroleum product turned out to be an important criterion for miscibility. Work on hydrogenation of castor oil has already been mentioned. Work is now in progress on formation of estolides from castor fatty acids at a temperature of 175°C. When heated, these estolides dehydrate at 250°C yielding products with a high conjugation of about 50%. The whole operation thus consists of two zones, one at 175° and the second at about 250° which may be carried out in succession. This is being studied in detail from the kinetic point of view.

6) Department of Applied Chemistry, University of Calcutta, Calcutta.

J. G. Kane : In the absence of a representative, I may say that work has been described in regard to the preparation of azelaic and sebacic acids in good yields by oxidation with potassium permanganate and nitric acid. The cost of 1 lb. of mixed dibasic acids is stated to be Rs. 8.49 nP.

A question has been sent in by Godrej Soaps (Pvt.) Ltd. as to whether any information is available on the darkening that occurs on storage of perfumed, refined castor oil used as hair oil.

K. T. Achaya : During bleaching with an activated earth, small degrees of conjugation are produced and might result in subsequent darkening of the oil. Possibly some of the perfumes used tend to darken on storage. They may also react with the hydroxyl group of castor oil to give dark-coloured products.

J. G. Kane (*in conclusion*) : The purpose of these discussions is to draw attention to the wider uses of castor oil. It is really gratifying to find that so much research is being carried out in India. This is only the beginning and I have no doubt that the fruits of the research now going on will be seen perhaps a decade later. We need have no fear about the future of castor oil if the pace of research which is taking place in India is maintained. There is certain to be an increased utilisation of castor oil in this country, and let us hope that such products will find good markets in outside countries also. Of course, restrictions such as import and excise levies will also come into the picture and many other factors will have to be taken into account. I would like to thank the organisers for having asked me to take the Chair during these discussions. I feel that I have benefitted as much as those present here. I would also like to thank all the research workers for having sent in their material and the audience for the excellent co-operation given to me.

SECTION B

CASTOR MILLING

&

SECTION C

BY-PRODUCT USES, STANDARDS & PRICES

DISCUSSION LEADER : *Dr. N. G. Chatterji,*
Oil Corporation of India (Private) Ltd.,
Calcutta.

SECTION B

CASTOR MILLING

Questions Raised

1. *Is decortication practised anywhere in India ? What decorticators are used ? Is there any difficulty ?*
2. *Does seed size affect decortication ?*
3. *Does relative humidity affect decortication ?*
4. *What are the expelling practices when decortication is not followed ? Cooking with steam gives an emulsion and oil loss : how much does this amount to ?*

   Does controlled cooking with moisture improve oil yield, as with other seeds?
5. *Is there any effect of poor storage of seeds or length of storage on the oil quality (yield, FFA, colour) ? How are seeds stored ? What is the maximum length of storage ? What is the usual supply season and the usual crushing season ?*
6. *Do seeds obtained at certain seasons yield better quality oil than at other seasons ?*
7. *How much oil is left in cake ? Would removal of this* (e. g. *by solvent extraction*) *improve the demand and price of cake for fertilizer ?*

Notes Received

Decapsulation

1. By decapsulation is understood the removal of seed from the capsules in which the seed is borne on the spike. Each capsule contains 3 seeds. Seed is generally marketed after decapsulation.

   There are no mechanical decapsulators for castor capsules in popular use. After harvest the capsules are heaped in a lot, allowed to dry and either beaten with a stick, or a stone roller is passed on them and the seed is separated from the capsule coat. Though this is slightly crude and laborious, yet it is most economical in the sense that the farmer has to make no investment and he conducts the operation in his leisure period, of which he has plenty from February to April.

   During such decapsulation, there is usually a breakage of seed to the extent of 3-5%. The broken seed is no good for sowing, but is alright for extracting oil. Relative humidity does affect decortication. But in India this question does not arise since castor is harvested from November to March. Decorticating or threshing is done from December to March when the climate is dry and hot and the fruits dry quite well.

   (*L. G. Kulkarni, Hyderabad*)

2. (a) In India, decapsulation of castor is generally carried out by hand. Decapsulation is practised everywhere in India before the seed is marketed. This decortication is done by hand by the cultivator, and the seed marketed. Prof. Sharp, Agricultural Research Engineer under the United States Technical Aid Programme, has designed a hand decapsulator for castor ; this machine was tried by the oilseed section for separation of capsule from seed and was found to have 50% greater efficiency than human labour. Improvements on this design may result in an even better decapsulator for castor.

(b) The effect of seed size on decapsulation is indirect. Generally, seeds which are very bold in size do not have a well-filled endosperm. This generally results in more brokens than in the case of smaller-size seed.

(c) Relative humidity does affect decapsulation in the sense that there is not complete separation of testa from seed coat.

(Dept. of Agri., Govt. of Andhra Pradesh)

Decortication

1. (a) Decortication of castorseed is not the usual practice in North Indian mills. Wherever this is done, the machinery used is of the corrugated rollers type and the separation of the husk and kernel is carried out by air current from a blower. The machine is generally rigged up by the engineering department of the mill.

The main difficulty in the satisfactory working of such machines arises on account of the fact that the feed consists of seeds of varying sizes. It seems that this difficulty would be overcome to a large extent if the feed is first sorted out according to size.

(b) Moisture content of the seed does affect decortication which is facilitated by the absence of the same.

(N. G. Chatterji, Calcutta)

2. A report from French Equatorial Africa mentions that castorseed decorticators imported from the U. S. A. were not satisfactory for use on African castorseeds which have thinner shells than the American. Of several designs of decorticators then tried, one made by a French firm was found satisfactory, but it was found that in seasons when the relative humidity was excessively high, the decorticators would not work satisfactorily and it was necessary to instal pre-driers through which the seeds pass before reaching the decorticators.

(Reg. Res. Lab., Hyderabad)

3. Decortication of castorseed is considered to be essential for three main reasons :

(a) Erosion on the expeller is avoided if the seeds are decorticated.

(b) The pigment forming the inner lining of the shell can be isolated from the oil, if the seeds are decorticated prior to milling.

(c) The capacity of an expeller would be considerably increased if the seeds are decorticated.

As far as the Laboratory is aware, decortication is not practised in India.

There are two types of decorticators, impact type and disc mill type. The impact type has been developed and is used in the U. S. A., whereas in Africa and other places, such a type is not found to be suitable, due to the difference in the thickness of the shells.

The laboratory is procuring a disc-mill type of decorticator with hull separator and it is proposed to study :

i) the hulling characteristics of castorseeds under various conditions of moisture content, etc.;

ii) the difference in the quality and yield of castor oil with and without decortication ;

iii) the quality and yield of castor oil under various conditions of cooking and drying; and

iv) the effect of storage of seeds on the quality and the yield of oil.

(*Reg. Res. Lab., Hyderabad*)

4. The composition of castorseed from various countries is given below as ranges, with averages in brackets below :

Characteristic	Cyprus	Philip-pines	Brazil	Mostly Africa	India			
					Gencral	Bombay	Bombay	Andhra Pradesh
Reference	1	2	3	4	5	6	7	8
Hull	35-48	—	—	18-22	24·3-32·8 (28·7)	21·0	30	25·6-33·2 (29·2)
Kernel	60-65	—	—	82-78	—	79·0	70	66·8-74·4 (70·8)
Moisture	—	5·14	5·5	—	3·2-7·6 (5·3)	2·1	5·14	3·1-5·8 (5·0)
Oil	45-55	53·67	48·6	45-50	36·9-60·8 (47·4)	45·1	46·65	45·0-51·8 (48·0)
Protein	—	30·61	17·9	—	—	—	17·88	12·0-16·0 (14·8)
Carbohydrate ..	—	6·73	13·0	—	—	—	12·61	3·1-7·0 (5·0)
Crude fibre ..	—	—	12·5	—	—	—	14·99	23·1-27·2 (25·6)
Ash	—	3·85	2·5	—	—	—	2·73	2·0-2·2 (2·1)
Weight of single seed, gm. ..	—	—	—	0·13-0·74	0·16-0·53 (0·28)	0·17	—	0·19-0·26 (0·23)
Length of seed, mm.	—	—	—	—	—	—	—	10·3-11·5 (10·9)
Transverse width, mm.								6·8-7·6 (7·3)
Thickness, mm.								5·1-5·7 (5·4)
FFA of seed oil, %				0·4-5·2 (1·6)	1·1			0·04-1·1 (0·4)

References:—1 "Omega" Chem. Trade J. and Chem. Eng., 1923, **73**, 483; D. B. Jones, J. Amer. Oil Chem. Soc. 1947, **24**, 247

2. S. P. Padilla and F. A. Soliven, Philippine Agr., 1933, **22**, 498.

3. R. E. Kirk and D. F. Othmer, "Encyclopaedia of Chemical Technology", Vol. 1, Interscience Publishers Inc., New York, 1949, p. 239.

4. S. S. Gupta, T. P. Hilditch and J. P. Riley, J. Sci. Food Agr., 1951 **2**, 215.

5. "Report on the Marketing of castor seed in India." Marketing Series No. 55, Manager of Publications, New Delhi, 1950, p. 82.

6. A. Halenke and M. Kling, Landw. Vers. Sta., 1900, **64**, 51.

Also D. B. Jones, J. Amer. Oil Chem. Soc., 1947, **24**, 247.

7. S. Kutumba Rao, B. Appu Rao, A. Krishnamurthy, S. D. Thirumala Rao and K. S. Murti, Unpublished data.

(Oil Technological Institute, Anantapur)

Castorseed Milling

1. The seeds are cleaned by passing through seed cleaning equipment and then crushed in expellers. Preliminary cleaning of the seed prior to processing is desirable in order to improve the quality of the oil as well as cake. It is claimed by the industry that for producing high grades of refined oils, fresh seeds are required. If proper care is not taken in ensuring storage facilities the seed has a tendency to deteriorate. It may also get spoiled if it is stored in damp godowns. The seed should be stored in dry and properly built store-houses with facilities for circulation of air to keep the seed cool and to prevent any formation of heat during storage. This would be necessary if wastage of seeds is to be controlled. Generally the yield of oil does not vary much from seeds obtained from season to season.

   Expeller cake contains between 8 and 10% of oil. One or two solvent extraction units remove even the residual castor oil from cake by subsequent solvent-extraction methods. This will not only add to the economy of the oil mill but also augment the oil supply position.

   (Ministry of Commerce and Industry, New Delhi)

2. In milling castorseeds, the seed can be fed to the kettle either after crushing in rollers or directly as it is. It is heated with steam and some amount of open steam is injected to increase the moisture. Cooking with steam does not give an emulsion in significant quantity and no loss of oil takes place. The yield of oil is improved by cooking with moisture as in the case of other seeds.

   On an average 7% of oil is left in the oilcake.

   (Swaika Oil Mills, Calcutta)

3. In North India the usual practice is to feed the whole seed into the expeller (the so-called first pressing). The loose cake coming out contains about 16-20% oil and after proper cooking is passed through a second set of expellers (second pressing). The final cake may contain 6-7% oil.

The cooking of the first-pressed cake is usually done with jacket steam only and a small quantity of open steam is injected into the meal on rare occasions.

(*N. G. Chatterji, Calcutta*)

4. A process for extracting oil without decortication has been developed at the National Chemical Laboratory, Poona. This is a modification of the Russian process of aqueous extraction known as the Skipin Process. In this modified process, castor beans are first roasted and then ground into a meal before extraction with hot water. Small amounts of common salt, lime water and potassium nitrate are added to break the oil-water emulsion. It is claimed that the oil yield obtained is 14% on the weight of seed meal when the oil originally present was 17.5%, leaving behind a small quantity of 3.5% of oil in the meal. In any solvent extraction process, 2% of oil is left in the cake.

The investigations also reveal that extraction of oil with steam alone or with the help of salts, acids, bases and demulsifying agents gave a yield of 38% oil on the weight of seed meal; thus the oil-loss by steam is about 6% (J. P. Verma, *Proceedings of Symp. on Oils and Fats.* NCL, Poona, 7th November 1951, p. 130)

(*National Research Development Corporation of India, New Delhi*)

5. The press cake contains 10-20% oil. The residual oil can be extracted with hydrocarbon solvents when the extracted cake (castor pomace) containing upto 2% of oil, is left behind (Kirk & Othmer, "*Encyclopaedia of Chemical Technology*", Vol. 3, p. 211). This is an advantage; since the cake is not used as cattlefeed, it is unlikely that solvent extraction will decrease its value. Actual information is, however, not available.

(*National Research Development Corporation of India, New Delhi*)

6. Expeller castor cake contains on an average about 6% of oil. It is evident that the removal of this residual oil from the cake would render the cake more suitable for use as fertiliser.

(*N. G. Chatterji, Calcutta*)

7. The oil content of castorseed can be determined in the Laboratory by extraction for 6 hr. with petroleum ether (40-60°C) in place of

1 hr., with carbon tetrachloride as laid down by the AOCS method. Results agreeing to 0.1 to 0.5% are obtained.

(Oil Technological Institute, Anantapur)

STORAGE, SEASON AND OIL QUALITY

1. On storage of seed, an increase in the FFA. takes place and the oil is darker but no effect is detected on the oil yield.

(Swaika Oil Mills, Calcutta)

2. Castorseed remains good on storage for 3 years (*ICAR Farm News Release* No. 134). Work has been published on the influence of bagging (*Poona Agric. Coll. Mag.*, 1930, *22*, 13), and of climate and other conditions (*Agric. J. India*, 1921, *19*, 81) on the per cent oil in castorseed.

(National Research Development Corporation of India, New Delhi)

3. The Department of Agriculture, Andhra Pradesh has studied the effect of storage on the oil content of castor. There were four storage treatments of seed, *viz.*, in open trays, gunny bags, sealed kerosene tins and glass jars. The period of storage was 2 years. Analysis for oil content was carried out once every quarter, and the results showed that oil content was not affected either by the method of storage or the length of storage. Similar results have been reported from Madras State; even after 3 years of storage of castorseed in gunny bags, there was no deterioration either in free fatty acid or oil content.

Castor harvest commences about the first week of December and arrivals into the market are at their peak in the months of January and February. The crushing season commences soon after.

(Dept. of Agriculture, Govt. of Andhra Pradesh)

4. (a) In a study made in the United States, the changes in castorseed on five years' storage were studied. Castorseed stored well under normal conditions. The average percentage of broken beans in farmers' lots is only 3-5%, which does not affect the oil quality. After two years storage, the oil still conformed to the highest standards laid down; during the third year of storage and thereafter, only the colour fell below these standards. Such colour deterioration was enhanced by breakage. The oil content decreases by about 2% during five years of storage.

(b) Some work has recently been done at this Laboratory on storage of castorseed:

(i) Except for loss of viability, castorseed showed excellent storage characteristics both in laboratory storage, and when kept at 50°C and 80% relative humidity, as shown by the following figures. –

	Storage for three months	
	Laboratory	Accelerated
Viability %		
Initial	85	85
Final	36	6 (after only 25 days)
FFA %		
Initial	0.36	0.36
Final	1.05	3.88
Colour (10 times dilution 5.25- inch. Y + 5R)		
Initial	2.7	2.7
Final	2.8	3.9

(ii) When seeds were smashed the seed oil deteriorated rapidly. In 71 days the seed oil in the damaged seeds rose in FFA from 1.13 to 12.16 and 37.00% on laboratory and accelerated storage respectively. Colour also greatly increased. Wetting further hastened this deterioration.

(iii) Even cracked seed deteriorated rapidly as shown by the following figures for laboratory and accelerated storage (50°C, 80%R.H.) for a period of 60 days:

	Cracked seeds		Cracked & wetted seeds	
	Laboratory	Accelerated	Laboratory	Accelerated
FFA %				
Initial	1.91	1.91	1.91	1.91
Final	6.3	12.3	7.7	14.7
Colour				
Initial	3.1	3.1	3.1	3.4
Final	6.8	9.0	9.0	11.0

(*Reg. Res. Lab., Hyderabad*)

5. (a) Experiments conducted on storage of seed in (i) leaf (ii) gunny bags (iii) sealed tins, showed that there is no loss in the yield of oil (extracted by Soxhlet) even after three years' storage.

(b) Castorseed is not stored for long periods. Oil is expelled and exported. Being a cash crop, farmers dispose off the seed immediately after threshing. Generally seed is stored in gunny bags in godowns only for 1 to 6 months at the most. There is very little carry-over from one season to another, amounting at most to 5% of a total production of 70,000 tons all over India.

(c) Castor is harvested from November to March. Seed starts coming to the market from December to May. Crushing season is also December to May or further.

(d) Seasons have no effect on the quantity of oil. I have no information about oil quality.

(*L. G. Kulkarni, Hyderabad*)

6. (a) Storage of seed under poor conditions or for long periods materially affects the quality of the oil, especially in a rise in acidity and deeper colour. It is practically impossible to bleach, to the same Lovibond scale, oil from old seed as that from fresh seed.

(b) It seems that the export market regulates to a large extent the programme of crushing.

(c) Naturally, mature seeds give a better quality of oil. At the same time it is recognised that the locality from where the seed is obtained influences considerably the colour and acidity of the oil. Thus oil from Nizam seed can be bleached much better than others.

(*N. G. Chatterji, Calcutta*)

7. Season has no direct effect on the total oil content. Sometimes there appears to be an apparent loss in oil content of seed picked at the fag end of the crop season. This is because the filling of the seed formed from the last bloom on the plant is not complete, owing to hot weather conditions and complete lack of moisture in the soil. Therefore, the oil realised is low and consequently the percentage oil content appears to be low. But if well-filled seed is picked from the last bloom and analysed, there is found to be no difference in oil content.

(*Dept. of Agriculture, Govt. of Andhra Pradesh*)

SECTION C

BY-PRODUCT USES, STANDARDS & PRICES

Questions Raised

1. *The present uses of cake are only manurial because it is very poisonous to cattle. Has the cake ever been used after detoxification for feeding purposes? Efficient decortication will also be necessary since the sharp hull pieces tear cattle intestines.*

2. *Are any methods used in industry to determine the percentage of hulls in cake?*

3. *How much castor cake is sold in India and how much in foreign markets? Are the selling prices based on % nitrogen?*

4. *What are the prices of decorticated and undecorticated cake? What are the prices of edible oilcakes* (e. g. *groundnut, cottonseed*) *and of manurial oilcakes* (e. g. *castor*)*?*

5. *Are there any standards for castor cake used in trade? Is it desirable to fix ISI graded standards?*

6. *Is any work known where castor cake has been used as a source of proteins for synthetic fibres, as with groundnut?*

7. *Is there any market for castor hulls? What is its price?*

8. *Are any uses of castor hulls known, e.g. the possibility of carbonisation to active carbons?*

Notes Received

Uses of Castor Cake

1. (a) Castor cake is an excellent fertilizer because it is :

(i) rich in nitrogen (6.1%), phosphoric acid (2.55%) and potash (1%),

(ii) rates as high as organic fertilizers on the basis of nitrogen nitrified,

(iii) contains many secondary nutrients,

(iv) forms humus,

(v) decomposes slowly in the soil, assuring a steady supply of nutrient and

(vi) retains moisture well.

(b) The industrial uses of castor cake as a protein are based on the comparatively soluble globulin, which constitutes 60% of the protein. This can be obtained by extracting the meal with alcoholic or aqueous alkali or with 10% sodium chloride solution, followed by acidification with hydrochloric acid, acetic acid or sulphur dioxide. Yields may range from 10-50% of the cake. The following uses have been tried or proposed for such industrial protein derived from castor cake.

(i) It contains 18% of glutamic acid and is used in Manchuria as a source of this material. Glutamic acid is converted into sodium glutamate, an appetiser which confers a meatlike flavour.

(ii) Distempers of good quality have been made containing 10% of castor proteins.

(iii) Tempera (oil-bound distempers) of excellent quality containing 10% castor proteins have been made.

(iv) To replace casein plastics, castor protein was not very successful when used alone in plastic mouldings.

(v) Excellent wood adhesives resulted either in combination with lime and sodium silicate, or with formaldehyde, ammonia and trisodium phosphate.

(vi) Good preliminary results were obtained in use as a textile fibre, but this was not pursued in full.

Reg. Res. Lab., Hyderabad.

2. Apart from its toxicity, the portein in castor cake is of good quality with the following amino acid composition.

Amino acid, %		Amino acid, %	
Arginine	11.0	Phenylalanine	4.2
Aspartic acid	4.6	Proline	3.9
Glutamic acid	13.0	Threonine	3.6
Histidine	2.5	Tryptophan	0.8
Isoleucine	5.3	Tyrosine	3.2
Leucine	7.2	Valine	6.6
Lysine	3.4	Unaccounted	29.5
Methionine	1.5		

The only nutritionally essential amino acids which are low are histidine, phenylalanine and particularly tryptophan.

(*Reg. Res. Lab., Hyderabad*)

3. Typical analyses of castor cake are given below:

%	From whole seed (Indian sample)	From whole seed	From decorticated seed	Solvent-extracted meal
		(U. S. A. figures)		
Moisture	11.3	9.9	10.1	11.7
Ash	6.3	15.0	10.5	6.1
Oil	6.2	5.3	8.8	1.1
Protein	28.6	20.4	16.1	33.6
Crude fibre	37	19.1	21.0	36.5
Carbohydrate				37.0
Phosphorus (as P_2O_5)	-	2.8	1.0	—

The protein consists of 10% globulins (potential industrial protein), 16% albumins (which include the toxic material ricin), 4% proteoses (which contain the toxic allergen), and 20% glutelins (conjugated protein and non-protein nitrogen constituents). The phosphorus is mostly present as phytin.

4. Note on synthetic fibres from oilcake proteins.

Proteins made from several vegetable oilcakes have been used to make synthetic fibres. These include groundnut (Ardil), maize (Vicara) and cottonseed. The following four steps are involved in production of synthetic protein fibres :

(a) *Spin solution preparation.* This is to denature the protein and remove the bonds between protein molecules, thus uncoiling them and making them linear. About 20% protein solution is used, and the denaturing agent is hot sodium hydroxide. The solution is filtered and freed of air (degassed).

(b) *Coagulation.* The solution is extruded through fine orifices into an acid bath. This converts the protein from a dispersed to a highly-aggregated state. Salts are added to prevent hydration and swelling of the fibres. As many as 250,000 fine jet fibres may be collected together as a single twisted thread.

(c) *Stretching.* This gives the fibre lustre, tenacity and transparency. Water or aqueous soap solutions are used. The elongation obtained may be 150-500%.

(d) *Hardening.* This imparts a high chemical resistance to the fibre. Usually formaldehyde is used and functions mostly by combining with the free amino groups of the proteins.

(*Reg. Res. Lab., Hyderabad*)

5. (a) Castor cake contains approximately 35% of proteins and the following work on its utilisation for making fibres has been reported.

(i) Kamath and Kulkarni have reported that castor cake proteins show promise as a source of textile fibre. Conditions for extraction of castorseed proteins from defatted cake have also been standardised (*J. Sci. Indust. Res.*, 1960, *9 B*, 289).

(ii) A new plastic, "Rilsan," based on castor oil is reported to have been developed by 'Société Organico; a French Company (*Paintindia*, 1951, *1* (5), 22).

(iii) Synthetic fibres have been prepared from proteins of castor cake and it has been established that these can be made from any corpuscular protein (T. V. Subbarao, *Indian Soap J.*, 1952, *18*, 90).

(*National Research Development Corporation of India, New Delhi*)

Toxicity of Castor and its Removal

1. (a) There are three toxic compounds in castorseed. One is a mildly toxic alkaloid, ricinine, which is not considered very harmful. The other is ricin, an extremely poisonous protein which is present in quite large amounts. It can be detoxified by treatment of the meats or cake with steam; *e.g.*, during the cooking operation, ricin is rendered comparatively harmless. The third is a powerful, stable allergenic material of protein-polysaccharide nature which forms about 12% of the castor cake, and can be extremely dangerous for anyone allergic to it. Very recently, extensive laboratory work reported from the U. S. A. shows that this allergen can be destroyed completely by (a) heating the cake to 200°C for 1-5 hours, though the cakes were scorched slightly, (b) moist-cooking the meals with 1% sodium hydroxide, or better by autoclaving at 20 lb. per sq. inch pressure with 2% alkali, and (c) moist-cooking the meats with 2% sodium hydroxide and 10% formaldehyde, or 0.9% hydrochloric acid and 3% formaldehyde.

(b) Castorseed and cake are highly poisonous to man, to small and large animals, ruminants and non-ruminants. The following doses of castor seed will cause death :

	No. of castor seeds
Man	6
Rabbit	1
Sheep	5
Ox & Horse	6
Pig	7
Dog	11
Cock & Duck	80

Horses when fed castor cake either died or were badly disabled. Fowls can tolerate it some what better but tend to lose weight. Reports indicate that fish are apparently not affected by the toxic properties and may be fed with castor cake. In any consideration of feeding castor cake, apart from the removal of the toxicity associated with the proteins, the purgative nature of the residual oil must also be considered.

(*Reg. Res. Lab., Hyderabad*)

2. Detoxification of the cake is carried out by autoclaving the moist cake, and by treatment with solutions of sodium chloride, ammonium sulphate, sodium hydroxide, etc. Toxic cake produces a deep-blue colouration with ninhydrin whereas the detoxicated cake produces a faint-blue colouration. This serves as a test for detoxication. Detoxicated cake has been fed to weanling albino rats and has also been tested by the agglutination test. Cake obtained from solvent extraction is found to be more toxic than expeller cake.

(*K. K. Dole, Poona*)

3. In this connection one is tempted to ask whether in India it is at all worthwhile to devote attention to the use of castor cake for edible purposes when any amount of other superior oilcakes are avaiable in the country for the cattle-feeding.

(*N. G. Chatterji, Calcutta*)

4. The Cattlefeed Sub-Committee of ISI has not considered castor cake as a feedstuff. In fact it has specified that other oilcakes should be free from even the minutest residues of castor husk. Importers of oilcakes in U.K are very particular about the residual castor husk in oilcakes. The suitability of this cake as a feed even after detoxification is yet to be established.

(*ISI Directorate, New Delhi*)

5. (a) The press-cake contains 10-20% oil and high percentage of proteins. After extraction with solvents it contains up to 2% of oil and approximately 35% protein but is unsuitable as cattlefeed because of the presence of the toxalbumin, ricin, which is highly poisonous to men and animals. Moreover the pomace contains a heat-stable allergenic substance derived from the original beans which powerfully affects many animals and humans. Castor cake possesses many desirable features ; it releases its nitrogen slowly, contains other elements of plant foods, and is high in humus value.

Castor cake can be used as cattlefeed as it is reported that ricin can be inactivated to some extent by steaming or otherwise heating the meal. Such methods have been claimed, but not proved to result in a meal suitable for cattlefeed [Kirk & Othmer, *Encyclopaedia of Chemical Technology*, Vol. 3, p. 240].

The following work on detoxification of castor cake has been reported:

(i) Repeated extraction of castor cake with hot 95% ethyl alcohol has been claimed to detoxify the meal (Raymond Borchers, *Poultry Sci.*, 1949, *28*, 568 ; *Chem. Abstr.* 1959, *44*, 1208].

(ii) R. Kodras *et al.* have reported that autoclaving for 15 minutes at 125°C completely destroyed the toxicity present in the meal [*J. Amer. Oil Chem. Soc.*, 1949, *26*, 611 ; *Chem. Abstr.*, 1950, *44*, 857).

(iii) The studies of Amanullah Khan on the toxic principles of castor cake brought out that toxicity can be removed by the following processes:

a) When oilcake is heated for 2 hours at a temperature of 110-115°C with twice its volume of 1.5 N hydrochloric acid, toxicity is removed and the product is neutralised with NaOH or Na_2CO_3.

b) The removal of ricin can be brought about by treatment of the cake with oxidising agents.

c) Exposure of castor cake to ultraviolet rays also removes toxicity.

d) Boiling with water is also reported to remove the toxicity [*Oil & Oilseeds J.*, 1952, *4*, (12), 10].

(iv) Breton & Gregory claim to have rendered castor cake suitable even for human consumption by treating the cake with proteolytic enzymes, then with autolyzed yeast and finally with

autolyzed bacteria (*U.S. Patent* No. 2,509,511, dated May 30, 1950).

(*Natl. Res. Dev. Corp. of India, New Delhi*)

6. The presence of castor cake in edible oilcakes is strictly forbidden in advanced countries since it is highly toxic. The same oil mills are not permitted to crush both castor and edible oilseeds. The presence of castor cake in other oilcakes is generally determined in one of the two ways :

(a) The first method consists in estimating the presence of castor hull particles. The cake is sedimented with water. The heavier particles are treated first with sulphuric acid and then with alkali solution. The castor hull fragments show up as very dark pieces, which are picked out and examined microscopically where they show a characteristic structure.

(b) The presence of ricin can also be estimated. Soluble protein is leached out from the cake, and the presence of ricin in this soluble protein determined by the precipitate obtained with anti-ricin serum (supplied by Merck).

(*Reg. Res. Lab., Hyderabad*)

7. The methods used in the industry to determine the percentage of hulls in the cake are not known. The cake is mostly used as a farm manure. The estimated production of castor cake is of the order of 60,000 tons. Only small quantities are exported, mainly to Ceylon.

(*Ministry of Commerce & Industry, New Delhi*)

Standards for and Price of Castor Cake

1. Proposal has been accepted for the formulation of an Indian Standard Specification for castorseed cake for manure. Work is in progress.

(*ISI Directorate, New Delhi*)

2. So far no standards have beeen fixed for castor cake. The exports having been small, the need for fixing standards has not yet been felt. So far as is known castor hulls are used only as fuel.

3. If decortication—partial or complete—is encouraged by fixing ISI. graded standards for castor cake, based on nitrogen content, this would indirectly result in increasing the production of oil of good colour readily saleable in the export market.

(*N. G. Chatterji, Calcutta*)

4. The price of castor cake today in India is about Rs. 200 per ton.

5. The price structure of two edible oilcakes is summarised below :

(a) *Groundnut cake.* In 1955, the internal price (all figures in Rs. per ton) averaged about 145, varying from 115-170, while the price in U.K. market varied from 155 to 577 averaging about 500-520. Thus the internal price of groundnut cake in India was less than one-third the price in the London market. In 1956 and 1957, exports of the Indian cake were drastically reduced ; the internal prices rose to an average of about 210-230. For a greater part of 1958, exported cake held at a lower price of about 360-370, but the internal price kept increasing. Towards the end of 1958 and throughout 1959 and 1960, export prices again reached the levels of about 500 obtained in 1955, with the internal price steadily increasing to about 330-360.

The comparative price structure of groundnut cake in the U. K. market through 1955 to 1960, shows the strong influence of the international prices on both the export and the internal price of the Indian cake. The prices of the Indian cake were at parity with Nigerian and French West African cake.

(b) *Cottonseed cake.* The prices (in Rs. per ton) of decorticated cottonseed cake on both the U. K. market and the Indian market maintained steady levels through 1959 and 1960 with only slight fluctuations. On the internal market this steady figure was about 320, and on the export market about 170. Prices of decorticated cottonseed cake were usually lower by 40-50 than those of groundnut cake.

Undecorticated cottonseed cake sold in India at about 280-300. From about December 1959, there was also a demand for undecorticated cottonseed cake in London, the prices being about 320-340 ; such cake was from British East Africa, Argentina and America.

(Summarised by Reg. Res. Lab., Hyderabad from data supplied by the Ministry of Commerce and Industry, New Delhi)

6. (a) The estimates of production of castorseed and castor oil by 1960-61 are as follows (*A.I.M.O. Directory 1958, Industrial Survey Section, p. 94*) :

Seeds ('000 tons)	Oil ('000 tons)
161	56

Hence cake by difference would be approximately 1,05,000 tons.

(b) Price of edible cakes in April 1960 [*J. Ind. & Tr.*, 1960, *10* (6), 1025]

Groundnut Cake	*Rs./cwt.*
Kanpur	12.30
Bombay	19.20
Calcutta	19.20

Linseed Cake	
Bombay	16.30
Kanpur	17.40 (Feb. 1960)
Calcutta	19.50
Sesame Cake	
Bombay	21.40
Salem	21.40
Mustard Cake	
Kanpur	12.60
Coconut Cake	
Bombay	20.00
Kozhikode	20.00
Castor Cake	
Bombay	10.30
Kanpur	12.30

(*Nat. Res. Dev. Corp. of India, New Delhi*)

Other Castor by-products

1. *Use of castor stalks, castor husks, etc.:* Laboratory and pilot-plant trials at the Forest Research Institute, Dehra Dun and the former Industrial Laboratory, Hyderabad, had shown that castor stem pulp can be used for production of writing, printing and wrapping papers. The Hyderabad work showed that the use of 1% alkali for digestion at 80 pounds per sq. inch gave a 40% yield of bleached pulp leaving behind 30% of residual fibre. The work at Dehra Dun gave a 57% yield of pulp from unbarked castor stalks by the sulphate process. The beaten pulp was short-fibered with an average length of 0.91 mm. and an average diameter of 0.21 mm. Mixed with one-third bamboo pulp, it was used to obtain writing, printing and wrapping papers of good formation and satisfactory strength. Like mechanical wood pulp, which is also short-fibered, the pulp from castor stalks may be used to produce newsprint where strength is not of primary importance.

(*Reg. Res. Lab., Hyderabad*)

2. Castor husk comprises 25-30% of the seed with a fibre content of 48%. Not much work seems to have been done on the utilisation of husks. The seeds and other parts of the plant contain an alkaloid, ricinine, having insecticidal properties. Extracts from the leaves and other parts are claimed to control a large majority of insects that eat food

crops and are marketed under the trade name "Spra Kast" in U. S. A. (T. V. Subbarao, *Indian Soap J.*, 1952, *18*, 90).

(Natl. Res. Dev. Corp. of India, New Delhi)

DISCUSSIONS (SECTION B)

N. G. Chatterji : I think we cannot do better than to adopt the excellent pattern set by Dr. Kane yesterday of following the questions more or less serially. I shall expect much help and advice from those present here who have both practical experience and theoretical knowledge.

Q. 1 : Is decortication practised anywhere in India? What decorticators are used? Is there any difficulty?

Q. 2 : Does seed size affect decortication?

Q. 3 : Does relative humidity affect decortication?

N. G. Chatterji : There is some slight confusion existing in the use of the term decortication with respect to castor. Castor capsules each contain usually three separate seeds and the removal of this outer capsule could best be called decapsulation, though the term decortication is sometimes erroneously used. The Indian farmers dry the castor pods in the sun and then beat them lightly with sticks or perhaps even use light rollers. The seeds spill out and are cleaned by hand and sent to the market. In India, where labour is cheap, this is certainly an admirable method and it is questionable if machinery for decapsulation would be necessary or able to compete economically. During the off-season, farmers have enough time for such decapsulation. Decortication, of course, implies the separation of the hard or brittle individual seed coat from the soft white kernel or meats inside. Here we have to consider an important question, *viz.* the extent to which the quality of the oil is influenced by the crushing of whole seeds, of seeds entirely decorticated or of seeds partly decorticated. An opinion has been expressed in the notes that decortication is essential, and several reasons are stated. The general practice in North India is to avoid decortication altogether. The seed is first put through expellers of large capacity at comparatively low pressure to obtain first-pressed oil. The cake, which contains 20-22% oil, can now be treated in one of two ways : it may be passed through rollers and then heated, either with or without open steam depending on the practice of the particular mill, before passing through high-pressure expellers for a second pressing ; alternatively, the first-pressed cake may be directly passed, without cooking or rolling, through high-pressure expellers. Second-pressed oil is somewhat darker in colour than first-pressed, but usually the two are mixed in the tanks for further treatment.

P. Vallabhji : There is no general practice of decortication of castorseeds in India. I have seen only one factory in Salem which does decortication by hand, not by machine. There is definitely some wear on expellers if decortication is not done, but this is not excessive, while the colour difference by omitting decortication is very slight.

D. M. Merchant : We have practised decortication in our factory at Bhavnagar for the last 7 or 8 years. It is essential to have some preliminary treatment for the seeds without which it would not be possible to use improved milling procedures. It is first necessary to clean the seeds of dust. The seeds are then graded for size by means of suitable meshes since otherwise they would not be broken properly in the decorticator. Uneven size of seeds can lead to great loss in the decortication stage. The decorticator consists of two chilled iron rollers fed by a feeder roll. The distance between the rollers can be adjusted according to the size of the seed. The broken mass falls on a sieve from which the shells are blown away by a blower and the kernel particles collected below. The method is both practical and very successful. Decortication is essential to make a consistent, light-coloured, low-acid pharmaceutical grade of castor oil, since the shells contain 4% of oil of a very dark colour. Of course, some oil is lost by passage of kernel particles into the shell fraction. We use the shells in the boiler and to a small extent as a feed-back in the second pressing.

K. S. Murti : What is the proportion of shells removed ?

D. M. Merchant : About 95%. The residual 5% shells are sufficient to ensure roughage and good expelling. As I have said the oils are very pale in colour as a result of decortication but also contain more mucilage and fibrous material, and degumming and settling are correspondingly more difficult. On the positive side, the capacity of the expeller is greatly increased while the wear and tear and consequently the expenditure on spares is very much less.

K. S. Chari : Does the removal of shells really result in a lower colour ?

D. M. Merchant : With fresh seeds, there is not much difference in colour or FFA as a result of decortication. But the shells darken on ageing and then contribute greatly to colour and acidity.

V. Samuel : Do you refine your castor oil ?

D. M. Merchant : We ensure quality of our castor oils by several means. The first is by judicious choice and buying of seeds from dry areas in the country. Storage of seeds is done very carefully and under the best conditions that we can provide. Our oils generally contain less than 0.2% free acidity and are often as low as 0.05%. All our oils are refined by hydration, filtration and bleaching, but do not need alkali refining. We use Krupp expellers and modify them by using a reverse worm which pushes the seed back into the barrel. Though the percentage of oil in the cake is normally 16-22% in India, we prefer to give a lighter first pressing and leave 25% oil in cake. After the second pressing, this comes down to 5%. We do not carry out any solvent extraction.

K. S. Murti : What is the difference in price between undecorticated and decorticated castor cake ?

D. M. Merchant : There is not much demand for undecorticated castor cake and the price is the same as that for decorticated cake. However, I must again point out that decortication reduces the oil colour by about 50% in the red component.

K. K. Dole : Does the allergenic material reside in the shell or in the kernel ?

D. M. Merchant : We do not know we have sent samples for testing to some laboratories.

M. Narayana Rao: We would like to know more about the two types of decorticators which are used for castorseed.

K. S. Chari : The impact type of decorticator is normally used in the U. S. A. and the disc mill type (which we are obtaining for this laboratory) in Europe. In the impact type, the seeds are thrown towards the periphery by centrifugal force and are broken by impact against a rotating disc. The principle is the same as that of a disintegrator. The disc mill decorticator comprises two types : in one both the discs rotate, and in the other one disc is stationary. The impact type of decorticator is not found suitable for seeds derived from the Continent and from French Equatorial Africa. Moreover, for our work, we needed a unit with a capacity of one ton of seed per 8 hours and only disc mill types were available of this capacity. Castor shells appear to vary greatly in different areas of the world. An American paper states that Brazilian castorseeds which were easily decorticated in Brazil had hardened on reaching the U. S. A. and could be decorticated only with difficulty. However, the Brazilian seeds when grown in the U. S. A. did not have hard shells.

One of the strong reasons in favour of decortication is the reduction in erosion on the expeller. Further the first-pressed oil will conform straightaway to medicinal quality specifications even without refining. The capacity also would greatly increase ; in one case, the capacity was stated to be 12 tons without decortication and 25-30 tons when decortication was practised.

K. S. Murti : I have observed castor milling both in the New England States of the U. S. A. and subsequently also in England some 12 years ago. There was then no decortication, and the first pressing was usually done in hydraulic presses with heating, and the second pressing, also in hydraulic presses, at higher pressure. Of course, solvent extraction of the cake was also done in the U. S. A. even then. In Kanpur, hydraulic pressing is still used and in Calcutta expellers are used. There is a fine unit, unfortunately not being worked, quite close to Hyderabad at Jedcherla, which has both seed-cleaning and decortication equipment made by Andersons. The shells after decortication are blown away, and the meats dried in a rotary drier. Following this, light hydraulic-pressing is carried out, followed by expeller-pressing at high pressure in Anderson Red Lion units.

Of the three advantages of decortication which have been mentioned, I would like to emphasise the factor of erosion when hulls are present. This

is greater for castorseeds than, for example, for groundnut which has no shell. It is unfortunate that the cake obtained after decortication, which contains more nitrogen, does not have a price premium. This is a tremendous disadvantage to the miller who practices decortication. May I suggest to Mr. Merchant that the loss of meats with the hulls, which he has mentioned, could perhaps be reduced by shaking the hulls vigorously, as is done with cottonseed in a tailings beater ?

R. G. Krishnamurthy : The general opinion appears to be that darker oils of higher FFA are obtained without decortication. Has anybody any quantitative data ? Both petroleum ether and alcohol give light-coloured oils by solvent extraction, the former at a higher and the latter at a lower temperature owing to different temperatures of miscibility of castor oil. Is there likely to be any difference in colour between such solvent-extracted oils and expeller oils ?

B. S. Kulkarni : I was associated in 1954 at the Southern Regional Research Laboratory, New Orleans, U. S. A. with some work on the filtration-extraction of castor, which has only very recently been published in the *Journal of the American Oil Chemists' Society* (1960, *37*, February issue, 92). Though it has been stated in this paper that there was no effect of hulls on the quality of castor oil, which was always of grade I both with and without decortication, this is probably due to the mild cooking conditions, and the low temperature used for solvent extraction. I do feel that there is a connection between hulls and colour which probably becomes manifest at the high temperatures, moisture levels and pressures obtaining in the barrel during expelling. It is relevant that the colour of second-pressed oils is distinctly higher than that of first-pressed oils.

K. T. Achaya : We have some evidence to support the connection between hulls and colour. During storage work on castorseeds at a temperature of 50°C and a humidity of 80%, it was noticed that the outer seed hulls became very dark. This was especially so when the seeds were wetted. It is certain that the pigment colour intensified during storage at high temperature and humidity.

N. G. Chatterji : To summarise briefly the points so far, it appears that the outer shell, especially at high temperature and moisture content, contributes some colour to expelled castor oil. Decortication, perhaps only partially in order to maintain expeller friction, would be desirable for oil of better quality. For effective decortication, seed-grading according to size will be essential. Corrugated rolls and rollers could easily be rigged up, and the conditions standardised for Indian seeds. Perhaps the shells could be mixed with the charge for the second pressing. Humidity is certain to affect decortication since the hull brittleness will be affected. I might also point out that crushers in North India are quite convinced that they will have less trouble with bleaching oil from Nizam seed derived from Hyderabad, than from certain north Indian seeds. I have had an interesting experience very recently in this regard from seed lots obtained from Sultan-

ganj and Gaya which are only 100 miles apart. The latter bleached excellently but the former gave a darker colour.

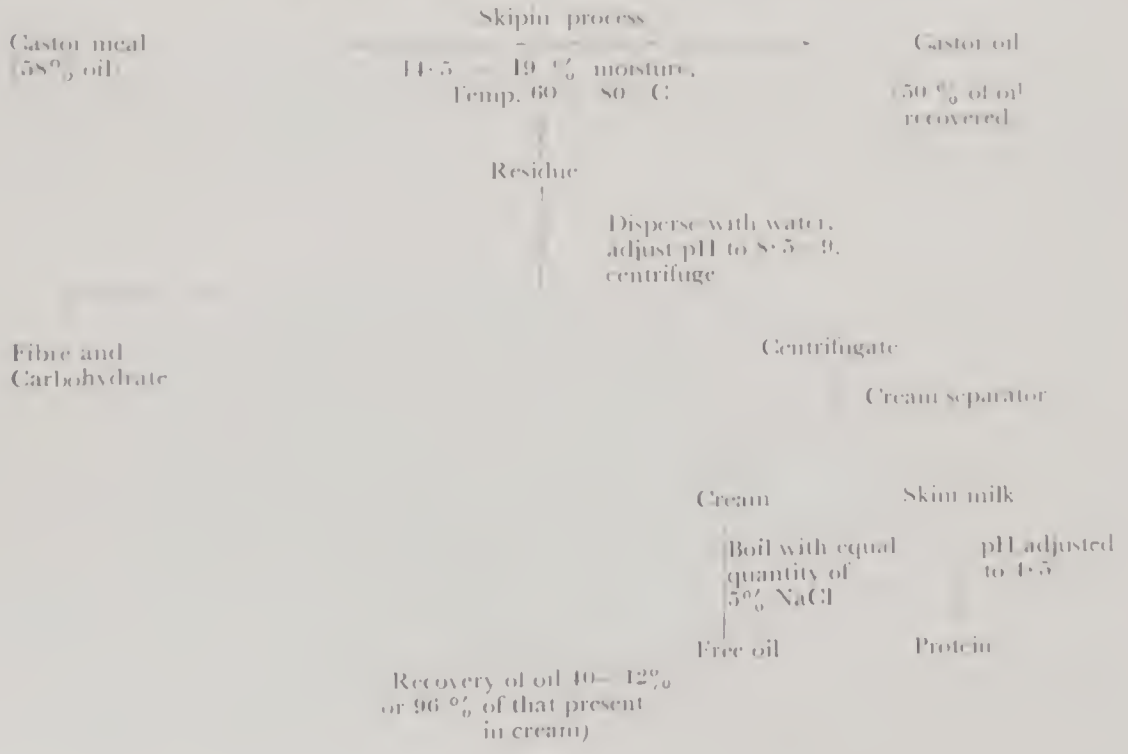
Q. 4 : What are the expelling practices when decortication is not followed? Cooking with steam gives an emulsion and oil loss : how much does this amount to? Does controlled cooking with moisture improve oil yield, as with other seeds?

Q. 7 : How much oil is left in cake? Would removal of this (e.g. by solvent extraction) improve the demand and price of cake for fertiliser?

N. G. Chatterji : I have described the general practice of castor milling earlier. I might just add here that sometimes the rolling of first-pressed cake is not done before the second expelling. This is desirable since cooking releases the oil much more easily.

K. T. Achaya: In a modern castor oil mill which we visited, the meats were treated with a large amount of steam. On expelling the oil, a very large amount of sludge was produced as a slimy emulsion containing a great deal of oil which could not be recovered even by centrifugation. I wonder if this is a general difficulty because it would appear that the oil loss is likely to be considerable.

M. Narayana Rao: A process was patented from the National Chemical Laboratory, Poona, some years ago in which castorseed was heated with water and salts at 95-100° C when the oil was obtained. At the Central Food Technological Research Institute, we have successfully used a wet-rendering technique for processing groundnut for both oil and protein of very high quality (*J. Amer. Oil Chem. Soc.*, 1959, *36*, 66). The same technique can be adopted for processing of castor to give again high-quality oil and protein. The integrated process can be schematically represented as follows:



The total yield of oil is 90-92% of that present in the meal, distributed as follows: 50% as Skipin oil, 40-42% in the cream and 8% distributed in the protein and carbohydrate fractions. The advantages of the method are that 50% of the oil is always of a very high grade since it is obtained by the Skipin process which is known to give quality oil, and even the 40% derived *via* the cream is of very high quality since pigments are not extracted at the pH of 8.5-9 which is used. Moreover, the protein is of very high quality with a nitrogen content of 14-19.5% and can be used for industrial purposes.

J. S. Aggarwal: There appear to be some drawbacks to this process. Breaking the oil-emulsion layer is not easy. The cake contains a large amount of water and would be difficult and expensive to dry or transport, apart from the likelihood of deterioration. The 8% of oil which is not recovered anywhere would probably render the process uneconomic. I fear that I see many difficulties with the contention that the method can be worked as a cottage industry. How will the farmer deal with the large amounts of fermenting aqueous slurries?

N. G. Chatterji : The main difficulty appears to me to be the one of drying the cake as quickly as possible. The colour of the cake is certain to darken during such drying. Let us hope however that the integrated process, which is claimed to give both cake and oil of good quality, will surmount the various difficulties that have been raised.

To return to the remaining question of the percentage of oil in cake by the usual expelling process: using hydraulic presses of rather old design (1918-20), the oil in cake was never below 7%. Using expellers, earlier we were only able to get a value of about 7%, but with experience this gradually came down, using the same machinery and the same workmen, to 6.4-6.8%. When everything is going well and the best adjustments are made, the lowest percentage of oil in cake is about 5.4-5.8. I would say that the average is about 6%. Removal of this oil by solvent extraction would not affect the price of the cake, since this is not used for edible purposes. The price is the same for expeller or solvent-extracted cake.

R. Sankaran: The removal of oil from cake would improve it for use as a fertiliser.

Q. 5: Is there any effect of poor storage of seeds or length of storage on the oil quality (yield, FFA, colour)? How are seeds stored? What is the maximum length of storage? What is the usual supply season and the usual crushing season?

Q. 6: Do seeds obtained at certain seasons yield better quality oil than at other seasons?

N. G: Chatterji: It stands to reason that if the seed is not stored in good condition and especially if moisture is present, this is bound to affect the quality of the oil and its subsequent removal. But in the case of castor, because of its thick shell, the storage damage in practice is fortunately very much less

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than with other oilseeds. This is supported by the research work reported in the notes from the Regional Research Laboratory, Hyderabad.

A large majority of oil mills store their seeds in stacked gunny bags. The more advanced mills try to provide a godown for storage under dry conditions sometimes even raising the floor level for purposes of ventilation and using stacked gunny bags which are periodically rotated. Not many mills will be able to afford silos for storage since the advantages may not be commensurate with the cost. The trend is definitely towards better conditions of storage.

P. Vallabhji: We feel that storage in bags, which allows for ventilation, is better than storage of seed in large silos.

N. G. Chatterji: Coming to the other questions raised, I would say that the very outside limit of storage would be about one year but that the usual length of storage would not exceed 5 to 6 months, depending on the activity of the mill and its sources of seed supply. In this period deterioration is negligible. Regarding crushing and supply seasons, information is available in the notes, *viz.* that the castor harvest commences about November and continues for 4 or 5 months. Arrivals of seed into the market are at their peak in January and February. The seed continues to arrive in the market till the end of May.

In my experience, there is little difference in the quality of seed arriving at different seasons of the year.

K. K. Dole: Enzyme action during storage causes heating.

L. G. Kulkarni : We have studied this subject of oil content and quality from the agricultural point of view. Cultivators harvest castorseed in three different seasons, *viz.* October-November, January-February, March-April, but we have found no difference in oil content between these three croppings. Fruits of the same spike ripening at different times also showed no difference in oil content. We have also stored seed for a period of 4 years in different ways as described in the notes. There was no change in content of oil and the FFA increase was only 0.1 to 0.2

D. M. Merchant: We have noticed that immature seeds give less oil.

L. G. Kulkarni: Since the fruits of castor are dehiscent, farmers have a tendency to remove the fruit before it is completely dry. Such seed contains about 20% less oil than fully-matured seed. To avoid this, we have developed varieties which do not shatter and therefore can be harvested after the capsule has dried completely.

We have not so far developed any varieties particularly suitable for machine harvesting. Mechanical harvesting has been used in Africa but is nowhere practised in India. Labour is cheap in India, the total cost of harvesting for 3 croppings being only Rs. 12/- per acre. Any machine must be cheaper than this, which is extremely unlikely. Though we have been

able to increase the yields to 300 to 350 lb. per acre, the soil is of very poor quality, in fact so poor that it will support only the growth of castor. Nor is manuring possible since manure is in very short supply. Of course, if the soil is good and water supply adequate, the same variety can yield as high as 600-700 lb. per acre. The yields can also be improved by developing hybrids, though there is a limit to this.

K. S. Murti : We had recently occasion to analyse 32 samples of castor-seed derived from Andhra Pradesh (Nalgonda and Mahabubnagar). For oil estimation, we first used carbon tetrachloride for 1 hrs. as recommended in the 1952 AOCS methods. Since carbon tetrachloride cannot be used on a water bath and needs a hot plate, we tried using 40-60°C petroleum ether for 6 hrs. instead ; the results agreed very well, and this procedure is recommended since it falls in line with the usual method of determining oil content. Later, we noticed that the 1959 revision of the AOCS methods has suggested the use of hexane, and an extraction time of 24 hrs. I do not know on what basis this prolonged extraction time has been suggested.

J. S. Aggarwal : Hexane is only a higher petroleum ether.

B. S. Kulkarni : At the Southern Regional Research Laboratory in America, *iso*-heptane was in use for determination of oil content.

Bharat Bhushan : It might be worth comparing oil extraction results using hexane for 6 hrs. and 24 hrs.

N. G. Chatterji: Oil millers regularly use hexane for a period of 3 hrs., *i.e.* till some 10 or 12 extractions have taken place, since this solvent is readily available to them. A very high degree of accuracy is, of course, not required,

N. Bhojraj Naidu : Carbon tetrachloride has the advantage of non-inflammability.

K. S. Murti : For laboratory determination there is no question of solvent inflammability complicating the issue, as with extraction in a plant.

S. Zainul Abideen : Instead of extracting oilseeds and oilcakes in a solvent extractor, the cake can be ground with sand to break the oil cells, placed in a funnel and extracted cold with solvent ; the oil is extracted in 10 to 15 minutes and the results are quite quantitative. A paper from the Indian Agricultural Research Institute, New Delhi, describes the method.

N. G. Chatterji : The method is satisfactory for seeds but not for oilcakes.

SECTION C

Q. 1 : The present uses of cake are only manurial because it is very poisonous to cattle. Has the cake ever been used after detoxification for feeding purposes ? Efficient decortication will also be necessary since the sharp hull pieces tear cattle intestines.

Q. 2 : Are any methods used in industry to determine the percentage of hulls in cake ?

Q. 3 : How much castor cake is sold in India and how much in foreign markets ? Are the selling prices based on % nitrogen ?

Q. 4 : What are the prices of decorticated and undecorticated cake ? What are the prices of edible oilcakes (e.g. groundnut, cottonseed) and of manurial oilcakes (e.g. castor) ?

Q. 5 : Are there any standards for castor cake used in trade ? Is it desirable to fix ISI graded standards ?

Q. 6 : Is any work known where castor cake has been used as a source of proteins for synthetic fibres, as with groundnut ?

N. G. Chatterji : The notes contain a good deal of data on removing toxicity from castor cake. However, there is such a dread of the poisonous material in castor cake that I do not think one will be able to get it used as a cattlefeed. There will always be doubts about the completeness of detoxification. Even the presence of traces of castor cake in linseed is determined with the utmost care by the methods given in the notes. From experience we are beginning to have doubts whether the dark fragments obtained by the bleaching method are always due to castor hull particles. It has recently been brought to our notice that, especially with linseed, there is another seed growing wild in the fields which gets mixed with linseed and gives dark fragments in the bleaching test leading to suspicion of castor. We are obtaining samples of this seed to send to the U.K. to confirm that they behave like castor hull particles in the bleaching test. I would like to enquire whether there is any other method for testing castor cake.

K. T. Achaya : Another very sensitive method using anti-ricin serum is described in the notes.

K. Krishnamurthy : After the bleaching test, the dark fragments are usually confirmed to be those from castor by microscopic examination.

K. K. Dole : In 1952, we had organised an exhibition on castor at which an ayurvedic preparation which contained castor seeds was offered as a specific for lumbago and sciatica. This got us interested in castor cake and we have studied the toxicity of the products from various mills. One Bombay producer produces a cake which is consistently of low toxicity, and therefore it would appear that suitable controlled processing would result in detoxification. It is comparatively easy to detoxify castor cake derived from decorticated castorseeds, since the allergenic material resides only in the hulls.

N. G. Chatterji : We had tried many years ago to feed detoxified cake to a goat. The goat appeared healthy, but after 30 days suddenly died though from what cause was uncertain.

K. T. Achaya : The toxic protein ricin is not a serious obstacle and can easily be removed by cooking. The main difficulty is to remove the highly toxic allergenic material which is of portein-polysaccharide nature and is quite

stable. Some American work to destroy this material has been described in the notes. Let us, however, rather think in terms of using castor cake as a source of industrial rather than edible protein. Its traditional use as manure will, of course, continue.

K. Krishnamurthy : One of the hindrances to the progress of the castor industry is the improper utilisation of by-products, especially castor cake. The cake cannot be used for edible purposes even though it contains a fairly good amount of protein because of the presence of toxic substances. The toxic materials ricin, ricinine and the allergen are all heat labile and soluble in water. It is necessary to compare the different methods of processing castor for the extraction of oil, to find out which gives the best quality of cake free from poisonous materials. The toxicity of the protein obtained by the CFTRI process is being tested and since it is a process involving water we are hopeful of a reduction in toxicity.

In any case, an attempt must be made to utilise the protein for better uses. Processing raw materials to improve the nutritive quality is well-known ; *e.g.* soyabean protein is greatly improved in nutritive value by proper autoclaving.

The use of castor protein for edible purposes may not appear to be a feasible proposition at present, but its importance may be recognised at a later date.

W. Thirumala Rao : I think it would be advantageous to retain castor cake for use as a fertiliser, to yield more food which the world needs so badly. The local uses of castor cake for manuring are most important for the future of agriculture and for the price structure of castor. It is particularly valuable against attack from white ants. Further, castor gives up its nutrients very slowly over a period of months.

N. G. Chatterji : The sale of castor cake within the country is not known since no records are kept. Figures are available for the export of castor cake. Though theoretically the prices for castor cake should be based on its nitrogen content, in practice it depends mostly on a broad prevailing price rather than on any particular criterion. There are no differences in the price of decorticated and undecorticated cake as was brought out in the discussion earlier this morning.

Regarding standards, I suppose it is always a good thing to fix standards for any product and that includes castor cake.

K. T. Achaya : I believe that draft standards of the Indian Standards Institution for castor cake are now being circulated for comments.

N. G. Chatterji : Regarding the use of proteins for production of fibre, a good deal of data has been given in the notes. However, it is a difficult business, and it is up to research institutions to continue work on these lines. It is certain that no one in India is now using castor cake for this purpose.

J. S. Aggarwal : It may also be significant that ICI has recently given up production from groundnut cake of their synthetic fibre "Ardil."

Q. 7 : Is there any market for castor hulls? What is its price?

Q. 8 : Are any uses of castor hulls known, e.g. the possibility of carbonisation to active carbons?

N. G. Chatterji : I do not think one can obtain any price at all for castor hulls. The hulls are mixed into cake and go back to the soil as manure.

K. T. Achaya : Since decortication is hardly practised in the country, probably the question of hull disposal or utilisation has not so far arisen.

N. G. Chatterji : The question may arise when decortication is practised more widely.

M. Narayana Rao : Work has been published from the Harcourt Butler Technological Institute, Kanpur (*J. Proc. Oil Technol. Assn., Kanpur*, 1955, *11*, 58) on the preparation of activated carbon from castor hulls by carbonising them after admixture with some metallic salts and phosphoric acid. It is stated that the products obtained were comparable to imported carbons.

N. G. Chatterji : Friends, we are at the end of this morning's session. We have been both teachers and learners, and I hope we have learned something and imparted something. I would commend very warmly the organisation of this Seminar in this rather novel way and thank the organisers for having asked me to preside. I thank you all for your co-operation.

SECTION D

CASTOR OIL QUALITY & STANDARDS

&

SECTION E

PRICE STRUCTURE OF CASTOR OIL

DISCUSSION LEADER : *Dr. R. Sankaran,*
Secretary,
Indian Central Oilseeds
Committee, Hyderabad.

SECTION D

CASTOR OIL QUALITY & STANDARDS

Questions Raised

1. *Is there ever any difficulty with bleaching raw or refined castor oil? How are such oils bleached ?*

2. *With solvent-extracted oils, is there any special difficulty of high FFA or colour ?*

3. *Is there any demand or price premium in export of low-acid oils to advanced countries ? Is there any need for a refining procedure ? What are low FFA oils particularly required for ?*

4. *Are oil characteristics like acid value and acetyl value related to maturity of seed, type of seed, length of storage, season of seed supply and method of processing of the crude oil ?*

5. *Are the present ISI standards for castor oil satisfactory ? Can the best grades be produced normally without difficulty ?*

Notes Received

Quality and Decolourisation of Castor Oil

1. Reports from America state that a dark colour in castor oil is normally associated with the presence of hulls during expelling or solvent extraction. Expelling without decortication should therefore result in dark-coloured castor oils.

(Reg. Res. Lab., Hyderabad)

2. (a) Castor oil is bleached in the usual manner with Fuller's earth and activated carbon. Bleaching of degummed and deacidified oils and bleaching under high vacuum, give better results.

(b) Unless the cake used for solvent extraction is old and rancid, there is no special difficulty of high colour or FFA with solvent-extracted oil.

(c) The experience of oil millers seems to support the fact that oil characteristics are related to seed maturity and quality.

(d) The present ISI standards seem to be satisfactory, though it must be admitted that with regard to colour it is almost impossible to reach the highest standard using indigenous bleaching materials.

(N. G. Chatterji, Calcutta)

3. (a) There is no difficulty in bleaching raw or refined castor oil. The oil is heated in a vat with or without vacuum arrangement to a temperature of 90-95° C and approximately 2% Fuller's earth and 0.25% activated carbon by weight of oil are added and stirred for half-an-hour. Then the oil is filtered off.

(b) With solvent-extracted oils, the FFA is higher than prescribed by the IS: 435-1954.

(c) There is no price premium for oils of lower acid value than 1. Since raw oil is generally of lower acid value than 4, there is no need for a refining procedure.

(d) Oil characteristics are related to seed maturity, storage and season.

(e) The present ISI standards are satisfactory. The best grades can be produced without difficulty.

(*Swaika Oil Mills, Calcutta*)

4. Bleaching of castor oil is done at a temperature of about 70 to 80°C with activated Fuller's earth. Higher grades of BSS. castor oil are obtained by further refining it with activated carbon. Some solvent extraction units had represented that solvent-extracted oil is dark-coloured as the oilcake obtained by them is not fresh. All grades of castor oil conforming to ISI., BSS., and USP. standards are being produced in the country.

(*Ministry of Commerce and Industry, New Delhi*)

5. (a) The Indian Standard Specification for castor oil, IS: 435-1954, covers the requirements for four grades of castor oil, including the medicinal grade, in respect of clarity, colour, specific gravity, refractive index, saponification value, iodine value, acetyl value, acid value, unsaponifiable matter, critical solution temperature and ash content of the oil. So far no difficulty in producing these grades in the country has been reported.

(b) Another Indian Standard IS:81-1950 prescribes the requirements for dehydrated castor oil, polymerized for paints. This material is used as a drying oil.

(*ISI Directorate, New Delhi*)

Low-acid Castor Oil

1. There is a fairly good demand for low-acid oil of good colour, commonly called BSS. grade. It is very difficult to reduce the acidity of the oil by the usual alkali-refining process. It would be a great boon to the industry if a simple process for reducing the acidity of the oil is worked out and made known to it. The method of steam distillation under high vacuum is found to be too expensive for the purpose.

Most industrial users of castor oil specify oils of low acidity (A. V. not more than 3).

(*N. G. Chatterji, Calcutta*)

2. (a) *Need for refining.* Unlike other vegetable oils, the refining of castor oil generally involves no alkali treatment, but merely implies precipitation of mucilage by hydration, and bleaching with active earth and/or carbon. Moreover, expelled castor oil is generally of low free acidity and this is no drawback in a majority of its uses. Recently, however, a neutral oil has been demanded by the lubricants industry. For hydrogenation to a hard, wax-like material also, a high degree of acidity would cause catalyst failure by metal-soap formation. The growth of the solvent-extraction industry will result in high-acid, coloured oils whose quality would always bear upgrading.

(b) *Refining technique for castor oil.* Indian Patent No. 69,383 (1959) issued to the CSIR covers the method worked out in this Laboratory for deacidification and bleaching of castor oil. Sodium carbonate solution is used for refining and, careful temperature control during the removal of soap is necessary. Refining losses are only slightly higher than theoretical. Bleaching after refining yields a further colour reduction and the final bleached colour is lower than that which is obtained by direct bleaching of the crude oil. The soap content of the final oil is about 100 p. p. m. The typical data are shown below:

	Sample 1	Sample 2
FFA of crude oil, %	3.7	6.4
Raw oil colour (1-inch, Y+5R)	10	35
FFA of refined oil,	0.6	0.2
Refining loss, %	2.5	9.5
Refined oil colour (as above)	13	27
Bleached oil colour (as above)	10	17
Colour of directly bleached oil (as above)	11	27

A refining method for castor oil has recently been published by Polish workers. A French translation appeared in *Oleagineux*, 1958, *13*, 855. Use of sodium carbonate gave only poor FFA reduction, *e.g.* from 9.6 to about 1.1 only. When sodium hydroxide was used it was essential to first add to the oil 8% sodium chloride solution followed by bubbling of the mixture for 15 minutes with direct steam. On this bed of salt solution, alkali refining is carried out with an optimum of 6-8% sodium hydroxide at 60-70° C using slow stirring of 35 r. p. m. The soap is centrifuged or washed away with water and the final soap content is low. Bleaching

with 2-5% of active earth-active carbon mixture gives a colour reduction of 30-45%.

(c) *Lowering of acetyl value by refining.* A French paper states that certain castor oils after refining treatment show an abnormally low hydroxyl value.

(*Reg. Res. Lab., Hyderabad*)

3. (a) *Need for low-acid oils.* Light coloured oil will be needed for the newer products being developed, such as urethane foams. Low-acid oils will be necessary for use as high-class lubricants in machinery, such as bearings, in aero-engines and as hair tonics.

(b) *Refining of castor oil.* Various techniques using sodium carbonate (as solid, as solution and in various excesses) were tried for deacidification of castor oil. FFA was reduced from 0.58 to around 0.09% with an average refining loss of about 5%. The soapstock floats at moderate speed and there is no emulsion problem. The crude oil colour of 19 (1-inch cell, Y+ 5R) was not reduced on refining, but on bleaching (2% activated earth plus 0.2% active carbon mixture) this came down to an average of 4.3.

Refining of castor oil on a layer of brine with 12° Bé. lye reduced the FFA from 4.3 to about 0.3 with a refining loss of 7-8%, while the colour reduction was from 11.5 for crude oil to 2.7 - 3.0 for the refined and bleached oil.

Spraying week lye over the castor oil did not result in emulsions. This method appears to have possibilities, and further work is in progress.

(*D. Mritunjaya Rao, M. Satyanarayana, S. D. Thirumala Rao & K. S. Murti, Oil Technological Inst., Anantapur*)

Storage of Castor Oil

1. (a) In studies at this Laboratory, castor oil was found to store extremely well. Three months' storage in the Laboratory and at 50° C - 80% R. H. gave the following figures:

	Storage of crude oil		Storage of refined oil	
	Laboratory	Accelerated	Laboratory	Accelerated
FFA %				
Initial	0.66	0.66	0.70	0.70
Final	2.75	1.62	0.72	1.18
Peroxide value				
Initial	4.66	4.66	4.89	4.89
Final	4.61	4.96	4.92	8.21
Colour (0.25-inch cell, Y+5R)				
Intial	2.5	2.5	1.5	1.5
Final	2.8	3.3	1.6	2.3

The greater degree of increase in FFA during crude oil storage at room temperature over storage at high temperature is noteworthy and further work to confirm this is in progress.

(b) The stability of castor oil to oxidation is also remarkable. On incubation at 63°C, crude castor oil had a peroxide value of only 17.1 after 164 days, and refined castor oil a value of 29.3 after 72 days. Thus even refined castor oil is more stable to oxidation than many other raw vegetable oils. The non-saponifiable matter contained a powerful antioxidant: on incubating non-saponifiable matter at a 0.2% concentration at 63°C with methyl oleate, the peroxide value of the material after 15 days was only 32.1 compared to 508.6 in the blank. The nature of the non-saponifiable matter is being examined.

(Reg. Res. Lab., Hyderabad)

SECTION E

PRICE STRUCTURE OF CASTOR OIL

Questions Raised

1. *What is the present position of India in the world castor market?*
2. *What are the factors affecting price in the Indian and world markets?*
3. *What are the present prices for various grades of castor oil?*
4. *What is the percentage production of Indian oil exported, and where?*
5. *What is the price of castor oil in (a) Brazil (b) India (c) on the world market?*
6. *Since a lot of Indian castor oil goes to America, and since America is to grow 22% of her needs (27,000 tons of oil in 1959), will exports suffer? Are there any recent importers (e.g. France for synthetic fibre)?*
7. *Do Indian exporters have any special difficulty in selling? Would any legislation or other incentives help to promote export?*
8. *Are there any complaints in regard to the quality of Indian castor oil and cake?*
9. *Is it advantageous to export castorseeds, or castor oil and cake? What are the relative prices?*

Notes Received

Price Structure in India

1. (a) Out of an approximate total production of 5,00,000 tons of castorseed per year, India's production will range between 20% to 25%.

(b) It is very difficult to say what are the numerous factors that affect the price in India and in the world markets, but the demand and supply position is the one which affects these prices as it does other prices. Particularly in the case of castor oil, where synthetics are fast replacing natural castor oil in various uses such as brake fluid, etc., the price level may be expected generally to remain low. However, viewed in relation to the growing demand from synthetic resin factories for castor oil, in the net result the price may not be much affected.

(c) The prices of various qualities of castor oil in the Bombay market (June 1960) were :

Castor oil BSS Rs. 19—3—0 per quarter

Castor oil commercial Rs. 18—2—0 per quarter

Both these prices are net naked ex-factory.

(d) Roughly speaking, something between 8,000 to 10,000 tons of castor oil are used for domestic consumption and the balance ranging between 30,000 to 40,000 tons is available for export.

(Swastik Oil Mills, Bombay)

2. (a) Supply of castor oil in India (Hindustan Lever estimates):

	1954	1955	1956	1957
Production of seed (lakh tons)	1.08	1.21	1.24	1.21
Export of seed	—	—	—	—
Sowing, etc., at 5%	0.05	0.06	0.06	0.06
Available for crushing	1.03	1.18	1.18	1.18
Oil production at 40%	0.41	0.47	0.47	0.47
Exports of oil	0.23	0.43	0.41	0.42
Net supply in tons available within the country	18,000	1000	6000	5000

(b) It was stated that 1957 was a bad year for castor in India for the following reasons:

(i) The crop was late.

(ii) Production was affected by drought.

(iii) A Government ban on imports of Fuller's earth for bleaching caused inconvenience.

(iv) There was a heavy export duty of Rs. 175 a ton, which was later reduced to Rs. 100.

(v) The freight of Rs. 200 per ton from India to the U. S. A. enabled Brazil to sell the oil much cheaper.

(Reg. Res. Lab., Hyderabad)

3. (a) India is second to Brazil in the production of castorseed. Production of castorseed in India and Brazil in the five years 1955 to 1959, is indicated below:

	Production ('000 tons)				
	1955	1956	1957	1958	1959
India	129	124	97	89	111
Brazil	161	166	196	N.A.	N.A.
Total world production	411	425	459	N.A.	N.A.

Source: Commonwealth Economic Committee's Report on Vegetable Oils & Oilseeds, 1959.

(b) Exports of castor oil from India and Brazil in the last five years were as under. While Brazil allows exports of castor beans also, export of castor beans from India is not allowed.

	Exports ('000 tons)				
	1955	1956	1957	1958	1959
India	42.1	42.2	12.4	20	35
Brazil	24.1	19.8	17.4	N.A.	N.A.
Total world exports	76.9	71.5	98.7	N.A.	N.A.

Source: Commonwealth Economic Committee's Report on Vegetable Oils & Oilseeds, 1959.

(c) Internal demand for castor oil is limited. Practically the entire production is exported. The price of castor oil is normally determined by the supply and demand position. The price is mainly dependent on the production. International prices and competition from other countries, namely Brazil, also affect the price level.

(d) The prices of two varieties, namely Commercial variety and BSS. variety, are available. Their prices in the Bombay market since January 1960 are indicated below:

		Price per ton in Rs.	
Date, 1960		Com. variety	BSS. variety
Jan.	9	1310	1410
	16	1430	1500
	23	1430	1505
	30	1460	1530
Feb.	6	1530	1600
	13	1530	1620
	27	1470	1535
Mar.	5	1450	1510
	19	1400	1470
	26	1400	1470
Apr.	2	1445	1510
	8	1440	1550
	16	1475	1530
	23	1450	1500
	29	1455	1515
May	2	1430	1510

Source: The Joint Chief Controller of Imports and Exports, Bombay.

(c) The percentage of production of Indian castor oil exported in 1957, 1958 and 1959 is shown below:

	Quantity in tons			
Year	Production	Exports	%	Buyers
1957	43000	42845	99	The main buyers are U. S. A., U. K.
1958	31000	20234	65	U. S. S. R., France, Australia, etc.
1959	38000	35156	92	

(Ministry of Commerce & Industry, New Delhi)

4. (a) The area and production of castorseed in India (1955-56) final estimates) is given statewise in the table below:

State	Area in thousand acres	Production in thousand tons
Andhra Pradesh	886	63
Bombay	344	34
Mysore	114	9
Madras	34	6
Bihar	29	5
Orissa	53	4
Madhya Pradesh	20	3
Uttar Pradesh	5	1
Assam	4	1
Rajasthan	3	Below 0.5
Kerala	Below 0.5	Below 0.5
Total	1,462	126

However, according to the *Review of the Commonwealth Economic Committee on Vegetable Oils and Oilseeds (1959)*, in India the "actual output of seed is greatly under-estimated by the present system of crop reporting which commonly omits castor intermixed with other crops. It is believed that output may in fact be practically double the quantity officially reported and, if this is so, India has been the world's largest producer in recent years with an actual production well exceeding that of Brazil."

(b) The estimated production of castor oil in India is given below:

Year	Production in tons	Source
1955-56	43,000	Indian Central Oilseeds Committee.
1956-57	34,000	-do- & Development Wing, Ministry of Commerce & Industry.
	*60,939	Central Board of Revenue.
1957-58	34,000	Indian Central Oilseeds Committee & Development Wing, Ministry of Commerce & Industry.
	*53,274	Central Board of Revenue.
1958-59	*33,648	-do-
	38,000	Development Wing, Ministry of Commerce & Industry.

*by factories whose annual production is more than 75 tons.

(c) The exports of castor oil from India as collected from different sources is given below :

Year	Export in tons	Value Rs. lakhs	Source
1956	38,936	—	Bombay Oilseeds Crushers' Association.
Apr.-Dec. 1956	34,811	—	Director-General, Commercial Intelligence & Statistics, Calcutta.
1956-57	41,445	—	-do-
	43,386	—	Central Board of Revenue.
	42,445	769	Development Wing, Ministry of Commerce & Industry.
1957-58	38,041	—	Bombay Oilseeds Crushers' Association.
	37,237	—	Central Board of Revenue.
	20,234	365	Development Wing, Ministry of Commerce & Industry.
Apr. - Nov. 1959	34,011	—	Director-General, Commercial Intelligence & Statistics, Calcutta.
1958-59	18,318	—	Central Board of Revenue.
Jan. -Jun. 1959	34,011	433	Development Wing, Ministry of Commerce & Industry.

(Oil Technological Institute, Anantapur)

5. (a) India and Brazil are the chief producing regions of commercial importance. Manchuria is known to be of potential importance *(Kirk & Othmer, Vol. 3, page 238)*.

(b) The area under castor, and the production of castorseed in 1957-58 and 1958-59, have been as follows :

	Area ('000 acres)	Production ('000 tons)
1957-58	1,181	89
1958-59	1,193	111

Source : *Commerce Annual* 1959, *Page* A. 214.

(c) Castor oil production during 1952-53 was 36,000 tons, during 1953-54 37,000 tons, and in 1954-55, 39,000 tons (*Progress of Industrial Development 1956-61, p. 406*).

(d) Indian prices of castor oil during March 1960 :

No. I Fine Pale	Rs. 60 —	Rs. 69.2 per maund
Commercial	Rs. 51 —	Rs. 56 ,, ,,
F. A. Q.	About Rs.	50 ,, ,,

Source : *J. Trade & Ind.*, 1960, *10* [15], 858]

(e)

Export of castor oil	Qty. (cwt.)	Value (Rs.)
1954-55	6,03,116	3,53,13,581
1955-56	7,78,716	1,09,36,676

The % of export to production in 1954-55 was 77.4%. The % of export to the U.K. in 1959 and 1957 was approximately 30% of total exports, while to the U.S.A. it was approximately 10% . Incidentally the export of castor oil to the U. S. A. in 1958 was very small (*Monthly Statistics of Foreign Trade of India & Foreign Trade & Navigation accounts of India, March, 1956*)

(f) Export of castor oil :

Country	1957		1958		1959	
	Quantity (cwt.)	Value (Rs.)	Quantity (cwt.)	Value (Rs.)	Quantity (cwt.)	Value (Rs.)
U.K.	2,56,924	2,42,21,365	1,76,998	1,26,36,474	2,21,001	1,49,42,220
U.S.S.R. ..	85,108	83,68,405	1,27,005	1,00,02,885	1,22,641	92,36,405
Germany (W.)	13,082	13,28,837	25,770	18,83,353	7,941	5,39,967
Czechoslovakia ..	20,400	20,03,306	14,710	10,95,764	—	—
Yugoslavia ..	—	—	10,000	7,49,058	—	—
Australia ..	23,741	23,96,126	19,775	15,79,126	24,326	18,65,904
Germany (E.) ..	—	—	—	—	5,400	3,94,200
France	43,942	36,60,984	—	—	30,286	21,29,445
U.S.A.	3,35,420	2,77,93,640	5,991	3,47,438	2,74,596	1,85,36,280
Netherlands ..	19,206	17,77,043	—	—	—	—
Other Countries	51,091	52,39,569	24,531	22,41,353	16,921	15,84,447
TOTAL ..	8,48,914	7,67,88,275	4,04,680	3,05,35,451	7,03,122	4,92,28,868

Source: *J. Trade & Ind.*, 1960, 10 [5], 858

(g) There are a number of countries importing castor oil, some of these being the U. S. A., U. K., U. S. S. R., Sweden, France, Germany (East & West). The exports to France from India during the past three years have been as follows :

	Quantity (cwt.)	Value (Rs.)
1957	13,912	3,660,984
1958	—	—
1959	30,286	2,129,445

Source : Monthly Statistics of Foreign Trade of India.

(h) India has not exported castorseed during 1957, 1958 & 1959. The export of cake from India was also negligible, being only 100 tons to Ceylon in 1957, and none during 1958 and 1959 to anywhere in the world. By inference it can be concluded that export of castorseed may not be advantageous.

The relative prices of these three commodities are given below during April, 1960 :

Castor seed

Vellore, Bhagalpur, Bombay	Rs. 28-28.50 per cwt. Hyderabad F. A. Q. quality Rs. 34.75 per cwt.

Castor oil

Calcutta	No. 1 Fair Pale	Rs. 91.5 per cwt.
Bombay	Commercial	Rs. 72.88 per cwt.
Kanpur	F. A. Q.	Rs. 87.10 per cwt.

Castor cake

Bombay	Rs. 10.23 per cwt.
Kanpur (Feb. 1960)	Rs. 12.30 per cwt.

Source: J. Trade & Ind., 1960.10 (6) 1024.

(*National Research Development Corpn. of India, New Delhi*)

6. Some castor statistics pertaining to India are given below:

(a) Castor in Andhra Pradesh

Out of a total Indian area (average for 1955-60) of 12.80 lakh acres under castor, Andhra Pradesh has the largest share of 7.39 lakh acres (58%). In

1958-59, the Indian acreage was 12.03 lakhs, and that of Andhra Pradesh 6.65 lakhs (55%). The 5 districts of Nalgonda, Mahboobnagar, Warangal, Hyderabad and Anantapur, together account for 5-16 lakh acres (78%), under castor, which is grown as a pure crop in this region. Because the soil is highly eroded and subject to severe drought, the yield is only 153 lb. per acre.

(b) Castor Seed Production in India During 1955-60

State	Quantity in thousand tons				
	1955-56	1956-57	1957-58	1958-59	1959-60
Andhra Pradesh	62	64	32	17	15
Bombay	35	35	25	30	28
Mysore	8	9	9	12	12
Madras	5	6	6	5	5
Orissa	4	4	4	4	4
Others	9	6	13	14	14
Total	123	124	89	112	108

(c) Castor Oil Production in India During 1955-59

	1955-56	1956-57	1957-58	1958-59
Castor oil (thousand tons)	13	13	34	38

(d) Utilisation of Castor Oil in India

	Tons		
	1956	1957	1958 (Provisional)
Textile industry	2,800	3,000	3,500
Axle lubricants	900	1,000	1,000
Paints and varnishes	500	550	550
Toilet preparations	500	600	600
Leather industry	400	500	550
Hydraulic brake fluid	250	300	320
Soap industry	100	100	100
Miscellaneous (including medicine)	2,800	3,000	3,200
Total	8,250	9,050	9,820

(e) Exports of Castor Oil from India

Export in tons

	To the U.S.A.	To the U.K	To State trading countries	To other countries	Total	Value in Rs. (lakhs)
1955	23,327	11,959	—	1,891	13,177	135
1956	20,377	13,711	—	6,570	10,661	607
1957	16,771	12,816	5,597	7,232	12,116	769
1958	299	8,850	7,631	3,451	20,231	305
1959	—	—	—	—	35,156	—

The decline of exports to U.S.A. in 1958 was due to the severe competition from Brazil and the high internal price of Indian oil. This high internal price was in turn due to the fall of production from 1,24,000 tons in 1956-57 to only 89,000 tons the next year. India again regained her foreign markets in January 1959 by exporing 31,011 tons as against, 18,530 tons during the corresponding period in 1958.

(f) Wholesale Prices of Castor Oil in Rs./Maund in the Bombay Market for 1956-1959

Month	1956	1957	1958	1959
January	11.25	63.12	11.78	19.96
February	38.00	51.81	15.90	19.31
March	11.37	55.12	18.85	18.94
April	18.50	59.25	19.96	19.19
May	18.12	60.25	19.12	51.15
June	12.50	54.37	19.31	51.11
July	12.12	57.25	53.72	16.16
August	16.25	52.87	51.15	14.81
September	11.12	54.37	51.84	17.75
October	18.75	54.00	17.84	17.75
November	61.25	54.00	16.83	51.06
December	63.19	18.12	18.91	53.63

It will be noted that the usual depression in prices which occurs when the crop normally arrives in the market, which in the case of castor is from November to February (being a *kharif* crop), does not obtain in the case of castor.

(g) Points from a Report of Shri C. V. Mariwala on "Marketing and Export Promotion" to the Ministry of Commerce and Industry in May 1957

(i) The consumption of castor oil is likely to increase in future years in the U.S.A. because of the increased demand for chemical derivatives for jet lubrication as well as for synthetic textile fibre.

(ii) India and Brazil are the main sources of supply. The U.S.A. is the most important market for Indian castor oil and efforts should be made to retain that market.

(iii) A high price level for Indian castor oil will tend to attract increased production in other countries, and/or development of chemical substitutes.

(iv) Castor has been sown in the U.S.A. on a trial basis and if successful, there is enough land and resources to grow a large portion of their requirements. Therefore, unless castor production in India is increased, prices will remain at a high level, and India's share in meeting the anticipated increased demand is likely to decrease.

(Indian Central Oilseeds Committee, Hyderabad)

Castor in the U.S.A. and Brazil

1. Prices of castor oil in the U.S.A. and of castorseed in Brazil during 1947-57 have been as under :

	Castor oil price in U.S.A. cents per lb.	Castorseed price in Brazil cents per lb.
1947	29.1	10.8
1948	22.7	7.1
1949	18.1	5.4
1950	20.1	7.1
1951	33.6	13.0
1952	28.9	9.8
1953	22.6	7.3
1954	17.2	5.2
1955	15.9	5.7
1956	19.2	7.7
1957	23.1	8.2

The extreme variability of nearly 100% between the prices of both seed and oil in different years is exceptional for a world oil.

(Reg. Res. Lab., Hyderabad)

2. Trade in castor in the U.S.A.

(a) Imports of castor oil

	% from Brazil	% from India
1950	98	2
1951	79	16
1952	42	36
1955	42	47
1956	30	57
1957	55	15

(b) *Recent domestic production of castor in the U.S.A.* In 1957, only 33% of oil and 20% of seed were imported into the USA compared to the previous year. In 1958, the U.S.A. produced 27,000 tons of castorseed or about 23% of their needs ; this represented a four-fold increase over their previous year's production.

(c) There was a drop in production of castorseeds from 11 million lb. in 1958 to 28 million lb. in 1959. This was mainly due to a drop in acreage from 23,000 to 17,000, all under irrigation. This drop was caused by unfavourable prices at planting time. Two-thirds of the 1958 crop came from California and half of the 1959 crop from Texas. The yield per acre rose from 252 lb. in 1952 to 1700 lb. in 1959.

(d) There has been a decline in consumption of castor oil from 182 million lb. in 1952 to an average of 130 million lb. in recent years. If all the 1959 crop is crushed, a yield of 13 million lb. of oil would be obtained and hence some 115 million lb. must be imported.

(e) The U. S. A. takes about 35 to 45% of the world trade in castor-seeds and oil. Following the policy of Brazil and India to crush seed and export oil, the trend in the U. S. A. is to decrease castor-seed imports (from 1,51,000 short tons in 1958 to only 10,000 tons in 1959) and to import more oil (from 3,000 tons earlier to 126,000 tons in 1959).

(f) The import duty to the U. S. A. is ¼ cent per lb. for seed and 1½ cents per lb. for oil. Imports of castorseed and oil into the U. S. A. from certain countries is given below :

Seed	Qty. in million lb.	Value in 000 dollars
Brazil	15.694	763
Haiti	1.665	100
Ecuador	1.116	70
Paraguay	0.388	16

Oil	Qty. in million lb.	Value in 000 dollars
Brazil	74.88	8,678
Angola	4.075	502
W. Germany	3.105	404
Peru	0.741	103
Netherlands	0.672	114

(*Reg. Res. Lab., Hyderabad*)

3. (a) The price today for the U. K. will be £ 126 and £ 120 per ton C. I. F. for Indian castor oil BSS and castor oil Commercial respectively. These prices work out at about Rs. 18.75 and Rs. 17.75 per quarter net naked ex-factory in Bombay. The prices on the Continent will be about £ 10 lower per ton because the competition from Brazil will be felt more keenly there than in U. K. where Imperial Preference operates. The price of Commercial castor oil in the U. S. A., which is practically the quality that the U. S. A. imports from India, will be about 15.00 cents per lb. C. I. F. which works out at about Rs. 17.50 per quarter.

(b) It is a reasonable fear that to whatever extent the U. S. A. is able to look after its requirements in castor oil by domestic production of beans, to that extent the export to that country will suffer both in quantity and in price.

(c) It may perhaps be that no legislative measures are necessary to promote export of castor oil. It is however as necessary for this product as it is for other products to have incentives to promote exports. While fixing these incentives or any similar measures, care will have to be taken to look after the interest of the growers, manufacturers and traders. This incentive scheme, if at all necessary, may have to be considered from various aspects to be effective.

(d) So far, we have not come across any complaint regarding quality of our castor oil. No castor cake is being exported.

(e) We consider it advantageous to export oil and oilcake instead of seeds. The price today for castorseed is Rs. 33.12 per cwt., and the price of cake is about Rs. 200/- per ton ex-mills. The prices of various qualities of oil today have been mentioned under 3 (a).

(*Swastik Oil Mills, Bombay*)

4. (a) Prices of castor oil in Brazil are not available.

(b) According to present indications our exports to the U. S. A. of castor oil will increase for some time to come, as its consumption in the U. S. A. is increasing by its new use in jet planes. The East European countries and the U. S. S. R. are also emerging as new buyers

of castor oil. Efforts are also being made to export castor oil to France and Italy for use in the manufacture of synthetic fibres.

(c) Indian exporters have no difficulties in exporting castor oil. Export duty on castor oil was abolished in July 1958. Full refund of excise duty of Rs. 112 per ton is being allowed on export. Export of castor oil has been decontrolled to save the exporters from payment of application fee for obtaining export permits.

(d) There are no complaints regarding the quality of castor oil exported to other countries. Importers in the U. S. A. and the U. K. consider the quality of castor oil arriving in these countries from India to be satisfactory.

(e) It is advantageous to export castor oil and castor cake as it helps the crushing industry in the country.

(*Ministry of Commerce and Industry, New Delhi*)

World Production and Other Activity

1. (a) World production of castor oil in lakh tons.

1935-39 (average)	2.00
1950-54 (average)	2.25
1955	2.10
1956	2.10
1957	2.40
1958	2.25
1959	2.30

The almost steady position contrasts with the overall increase of 1% in total fats and oils in 1959 compared to 1958.

(b) World production of castorseeds in 1958.

	'000 tons	%
Brazil	172	35.8
India	98.5	20.5
Thailand	36	7.5
U. S. A.	27	5.6
Ecuador	13.5	2.8
Transvaal	13.5	2.8
Others	119.5	25.0
Total world production	480	100

Average prices of castor oil in Rs./ton in the Bombay and U.K. markets (Indian and Brazilian oil) during 1957-1960

MONTH	1957		1958			1959			1960		
	Bombay	U.K.	Bombay	U.K.		Bombay	U.K.		Bombay	U.K.	
		Indian		Indian	Brazilian		Indian	Brazilian		Indian	Brazilian
January	1,788	2,350	1,254	1,520	N.Q.	1,359	1,423	1,276	1,536	1,617	1,685
February	1,548	2,193	1,256	1,514	1,396	1,341	1,403	1,296	1,503	1,677	1,667
March	1,559	2,049	1,316	1,608	1,423	1,318	1,410	1,313	1,416	1,565	1,640
April	1,646	2,143	1,371	1,652	1,450	1,346	1,416	N.Q.	1,459	1,641	N.Q.
May	1,740	2,210	1,334	1,608	Nom.	1,481	1,529	N.Q.	1,440	1,642	1,630
June	1,658	2,032	1,350	1,627	1,480	1,398	1,463	N.Q.			
July	1,646	2,036	1,378	1,580	1,462	1,264	1,423	N.Q.			
August	1,596	1,995	1,374	1,553	1,480	1,219	1,396	Nom.			
September	1,603	1,990	1,397	1,550	1,450	1,299	1,463	1,463			
October	1,595	1,970	1,324	1,508	1,363	1,299	1,523	Nom.			
November	1,524	1,851	1,242	1,465	1,325	1,389	1,583	1,602			
December	1,329	1,680	1,331	1,463	N.Q.	1,459	1,623	Nom.			

N.Q.=Not quoted Nom.=Nominal

(Indian Central Oilseeds Committee, Hyderabad)

(c) Castor activity in other countries:

(i) Salvador (Brazil) is setting up a modern plant to treat 20,000 tons of seed annually with plans to expand to 50,000 tons.

(ii) South Victoria (Australia) is setting up a castor oil mill.

(iii) Costa Rica: A castor oil mill has been proposed by a Japanese firm.

(iv) Vietnam is setting up a factory to absorb all its domestic production of 5,000 tons of seed.

(v) Bucharest (Rumania) has set up a factory to make DCO.

(vi) Bromborough (England) : The well-known factory of Prices at Bromborough, Cheshire is producing 12-hydroxystearic acid from castor oil for use in lubricants.

(vii) Marseilles (France): The Société Organico is producing annually 3,000 - 4,000 tons of nylon monomer from castor oil.

(*Reg. Res. Lab., Hyderabad*)

DISCUSSIONS (SECTION D)

R. Sankaran : The idea of first issuing questionnaires to obtain information followed by discussion at a Seminar is a novel and unique one. I appreciate the gesture of electing me discussion leader which I attribute to the magnanimity of oil chemists and technologists and to the regard for my work in the Indian Central Oilseeds Committee during the last few years.

Production, prices and export of any agricultural commodity like castor are all interrelated. Good statistics of production are available in the notes supplied and also in the Indian Oilseeds Atlas, published by the Indian Central Oilseeds Committee. The monograph on Castor recently published by the ICOC contains useful agricultural information furnished by Dr. L. G. Kulkarni, with a chapter on chemical aspects from the Regional Research Laboratory.

a) Production

Let us first consider the production of castor. The estimates of area and production in India are considered to be subject to an error of considerable magnitude because of the fact that the crop is generally grown as a mixture with other crops and not as a pure crop. The actual output of seed is underestimated by the present system of crop reporting which often omits castor when intermixed with other crops. According to the Review of the Commonwealth Economic Committee (1960), the output may in fact be double that officially reported. If this is so, India has been the world's largest producer in recent years, with an output generally much higher than that of Brazil.

The primary reporting agencies at present are village officers such as *karnams* and *patwaris* (village headmen) and their estimates are very subjective

and therefore liable to error. Better figures of acreage and production are being sought.

As I have said, castor is mostly grown as a mixture with other crops, or along the borders of crops such as sugarcane, turmeric, chillies, etc. There is considerable scope for increasing the area under castor without encroaching on the other food crops. Some of the measures for expansion of the area under castor in India taken by the Indian Central Oilseeds Committee since about 1956, may be briefly reviewed. In 1956, the Committee suggested that castor plants could be grown along irrigational canals and addressed the State Governments to take all measures to grow castor plants in this way. Schemes for the multiplication and distribution of castor, which the Committee would assist financially were invited and, the States urged to conduct surveys of areas suitable for castor cultivation and to encourage it wherever possible in Community Project Areas and National Extension Service Blocks. During 1957, the distribution of castorseed for cultivation as a border crop was linked with the Cotton Extension Scheme in progress in various States, while the possibility of cultivation along contour bunds was attached to Soil Conservation Scheme. In 1958, it was decided to distribute 10,000 lb. of castorseed free of cost for cultivation in 8 States, and a lump sum of Rs. 2,500 was placed at the disposal of each State for this purpose. Campaigns for expansion of area under castor were urged under the Oilseed Expansion Schemes, financed entirely by the Committee, and under the Oilseed Development Schemes financed jointly by State and Central Governments. In 1958 the Indian Central Cotton Committee again recommended the introduction of castor as a border crop for cotton in their work under the Cotton Expansion Schemes. In the same year, quantities of castorseed ranging from 4,000 to 16,000 lb. were procured and distributed by different States. In the next year, these quantities were further increased and several States have distributed upto 18,000 lb. of seed for cultivation as described earlier. Following this up, several States sent in their requirements of castorseeds for 1960-61 to a total tune of 1,55,000 lb. There are, therefore, encouraging signs that the acreage under castor is climbing slowly and steadily.

As a border crop along sugarcane fields, castor has been well taken to by cultivators all over India because an additional income can be obtained without prejudice to the yield of sugarcane. Moreover, the border crop of castor exercises a beneficial effect on the sugarcane as a wind-break as well as against cattle-grazing. One difficulty mentioned by sugarcane growers is that the ripe castor capsules shatter, and further that suitable varieties coinciding with the growing period of the sugarcane crop are not available. Botanists have since developed varieties of castor meeting both these requirements.

Where castor is grown as a pure crop as in Andhra Pradesh (as stated in the notes), there is considerable scope for stepping up yield per acre by adopting intensive measures of cultivation. This brings in the local availability of fertilizers, but I would like to say that government agencies are quite prepared to allot fertilizer quotas if production is stepped up. Of course, it is necessary that costs must not increase and that an individual profit must

be assured. If we ask the farmer to grow more, there should still be a worthwhile economic profit despite the inevitable fall in prices.

(b) Export of Castor and Utilisation in India

The opinion of Government is very strongly aganist export of oilseeds. The only exception is with groundnuts of exceptional quality which are exported in limited amounts for confectionery purposes. In this way, Indian industry is not starved; even at present, 50% of the installed capacity of Indian oil mills is not being utilised. Also, by internal expelling, the oilcake will be available within the country for use as manure and cattlefeed, and in this way is available for use in the locality in which the expelling is done.

The use of oilcakes as manure has unfortunately very much decreased because of emphasis on inorganic fertilisers. It is now fairly well recognised that for the manuring of any seed crop, a judicious mixture of organic and inorganic manures should be used, the organic manures being not merely oilcake but also animal and farm manure. Castor cake is a particularly valuable manure since in addition to its nutrients, it is also a deterrent to white ants. Karanj oilcake also has this quality. There are, of course, pressing demands from abroad for oilcake for use as cattlefeed, since there is a general shortage of herbage in Europe, both during winter or whenever there is a drought. Against this economic attraction to the Indian milling industry for sale of oilcake abroad, there has been a vehement and unanimous objection from every State Department of Agriculture to the export of both edible and non-edible oilcakes. The Commerce Ministry has taken the view that a certain amount of export is desirable in the interests of foreign exchange; for example, about Rs. 32 crores was the income from sale of groundnut oilcake alone during 1955-56. An incentive was provided by Government by linking oil exports with those of expeller cake: for every ton of oil exported, a quota of 3.5 tons of cake was allowed for export. Although the Government's export policy has been generally liberal, the results in the case of castor are reported to be far from satisfactory. Export duty leviable on castor oil was completely abolished in July, 1958. Further relief was given to the trade by allowing full refund of excise duty of Rs. 112 per ton on export instead of 11/14 which was normally allowed. Castor oil has been removed from the list of commodities controlled under the Export Trade Control Regulations, thus saving the exporters the payments that would normally have to be made for obtaining export licences. Thus the Government of India seem to have exhausted most of the avenues for providing relief to the trade.

(c) Prices

Prices are always difficult to assess and though some data have been provided in the notes, they are not sufficient to make a complete picture. The wide fluctuations in the price of all oilseeds and vegetable oils during the last five years is also visible in the Indian prices for castorseed and oil. From a peak price during November and December 1956, there was a downward trend towards the latter half of 1957. During 1958, the prices tended to remain fairly steady, followed by an upward trend in 1959. The distinctly higher

price of Indian oil over Brazilian oil obtaining in the United Kingdom market during 1957, gradually became less noticeable during 1958-59, and in 1960, the price was closely similar to that of Brazilian oil and the latter was sometimes even slightly higher. This is an encouraging sign and shows that India can compete with Brazil in the United Kingdom market. Figures are also available in the notes for the price of castor oil in the United States and the price of castorseed in Brazil, and these again show very wide fluctuations during the last 10 years.

Q. 1. Is there any difficulty with bleaching raw or refined castor oil? How are such oils bleached?

N. G. Chatterji: I would like to know what exactly is meant by raw or refined oil because neutralisation of castor oil is hardly ever practised.

K. T. Achaya: By refined oil is meant the oil from which mucilage has been removed. Sometimes these oils are difficult to bleach. Raw oils are taken to be cold-pressed castor oils.

P. Vallabhji: Fuller's earth and active carbon are added in vacuum for bleaching. We rarely have oils with an FFA above 1%.

J. G. Kane: The practice of removing mucilage from the oil by steaming with a large amount of water was found by us to stabilise the colour. If controlled heating below 100°C is carried out using indirect steam, followed by sprinkling with 1% hot water at 60°C, the mucilage swells and tends to settle. If the oil is now quickly raised for a short period to 100°C, clear separation occurs and the oil can be decanted or centrifuged. Use of a jacketed vessel rather than open steam coils will enable this process to be worked without difficulty. Such oil bleaches extremely well.

I would like Dr. Chatterji to amplify his complaint stated in the notes about indigenous bleaching earth.

N. G. Chatterji: The following colour data will support the contention:

	Oil 1		Oil 2		Oil 3	
	Y	R	Y	R	Y	R
Raw	15.3	1.0	19.3	1.4	19.1	2.5
Bleached 1st lot	2.0	0.3	4.1	0.3	4.6	0.4
,, 2nd lot	—	—	2.0	0.3	—	—

	Gaya oil		Sultanganj oil	
	Y	R	Y	R
Raw	17.8	2.4	18.1	2.6
Bleached	2.1	0.2	2.9	0.4

The bleached oil derived from gaya castor oil is of BSS quality, while that from Sultanganj oil, was not of BSS quality. Of course, the latter oil would also

be sold as the next quality, but would not qualify as BSS oil. In our experience Nizam seed from Hyderabad always gives castor oil which can be bleached to the highest quality, but with North Indian castorseeds the difficulty of bleaching is sometimes felt.

K. S. Murti: Refining of castor oil is not to be understood in the same sense as for other vegetable oils. All specifications prescribe an FFA above 2% but the colour requirements are fairly rigid (2.2Y + 0.3R for BSS oil). We had occasion recently to work on the refining of castor oil as a result of technical enquiries from the State. The literature describes three main methods, using straight caustic alkali, straight sodium carbonate and refining in solvent, all conducted with or without heat treatments. The process worked out by the RRL using sodium carbonate as earlier used by Klaychko also was found to work satisfactorily. Refining with a spray of caustic soda solution is also a good method. Refining of castor oil with caustic soda on a bed of salt solution is another process which gives good results. The main thing is to avoid emulsion formation.

K. T. Achaya: The refining of castor oil has long been a bogey in the trade but is not really so complicated, though careful control of process conditions is necessary. The need for castor oils of low acid value has been mentioned in the notes but may again be stressed. A neutral oil is in demand by the lubricant industry. For hydrogenation to hard products, a high degree of acidity might result in failure of the catalyst. Solvent extraction is often carried out on oilcakes which have been stored and are thus of poor quality; such oils are likely to be dark coloured and of high free acidity and would benefit by improvement in quality.

Q. 2: With solvent-extracted oils, is there any special difficulty of high FFA or colour?

Q. 3: Is there any demand or price premium in export of low-acid oils to advanced countries? Is there any need for a refining procedure?

N. G. Chatterji: Only about 500-600 tons of castor cake are solvent-extracted. Solvent-extracted oil from fresh cake is as good as expeller oil. But if the cake is old or comes from another factory, the colour of the oil may be dark. It is almost impossible to remove the colour from such dark-coloured oil. Since solvent-extracted oil comes out in the form of a miscella or solution in hexane, it would be worthwhile neutralising it in the miscella stage. In some simple experiments at the Harcourt Butler Technological Institute, Kanpur, such miscella was refined using lye of 20°Bé. and the soap flakes settled down and could easily be decanted or centrifuged. The process could easily be visualised on a large scale and I would urge research on the question of miscella refining for improvement of solvent-extracted castor oil.

R. G. Krishnamurthy: It is possible to extract castorseed directly and not necessarily from expelled cake. Refining can then be done in the form of miscella, thus avoiding an extra step and obtaining more oil.

R. K. Kochhar : Is any castor being solvent-extracted in India ? How could one distinguish between solvent-extracted oil and other types of oil? What happens to the toxic materials in the cake on solvent-extraction?

K. K. Dole : Solvent-extracted castor cake is even more toxic than expeller cake.

N. G. Chatterji : Castor oil of low acid value is in increasing demand by the large petroleum companies, who offer a better price than that available in the ordinary market. The specifications are such that it is worth the very slight extra effort of any oil miller to supply such material, since he can still make a fair profit. For the export market, the FFA requirements are such that they can easily be made by following the usual milling procedure. Some care is necessary in the selection of seed but this soon comes with experience.

Regarding the need for an alkali-refining procedure, this is only very occasionally necessary for off-quality oils. There is always the need, however, for ordinary refining *i.e.* demucilaging and bleaching, in order to achieve clarity and brightness.

V. Samuel : It is true that STANVAC use castor oil of very high quality, but this is part of a general policy, that to obtain a quality finished product, quality raw materials have to be used. I would say off-hand that the price for high-quality castor oil would be about Re. 1 per lb. STANVAC always prefers to buy direct from crushers, so as to avoid the profits of middlemen. They also prefer to have several sources of supply.

K. K. Dole : Hydraulic brake-fluids also require an oil of low FFA.

J. S. Aggarwal : It is known that the addition of 0.1% of fatty acids to mineral oils gives lubricants of very high quality, and the free acidity actually improves the quality. I would like to ask whether the presence of 1% FFA would do any harm.

V. Samuel : We are trying to eliminate FFA from lubricant oils. It is our experience that when vegetable oil is present in a mineral oil, the beneficial characteristics tend to become more evident when extreme pressure lubrication is required. So some fat material is beneficial though not in the form of FFA. Of course, beyond a certain amount, FFA in a lubricant will tend to harm the machinery.

Q. 4: Are oil characteristics like acid value and acetyl value related to maturity of seed, type of seed, length of storage, season of seed supply and method of processing of the crude oil?

R. Sankaran : (after calling for information): There appears to be no information on this question.

Q. 5: Are the present ISI standards for castor oil satisfactory ? Can the best grades be produced normally without difficulty ?

N. G. Chatterji : From both the information given in the notes and my own experience, I would say that the present ISI standards are quite satisfactory and are not difficult to attain. Of course, to get the best grades, a certain amount of special effort is needed.

K. T. Achaya : The other point is whether there is sufficient premium in price for oil of very low FFA to consider whether a fresh ISI standard for this quality is worth introducing.

J. G. Kane : Perhaps some guidance regarding standards for oil of very superior quality can be obtained by comparing the specifications of Stanvac with those of ISI.

N. G. Chatterji : STANVAC specifications are very close to those of BSS castor oil.

SECTION E

Q. 1: What is the present position of India in the world castor market ?

Q. 2: What are the factors affecting price in the Indian and world markets ?

Q. 3: What are the present prices for various grades of castor oil ?

Q. 4: What is the percentage production of Indian oil exported, and where ?

Q. 5: What is the price of castor oil in (a) Brazil (b) India (c) on the world market ?

Q. 6: Since a lot of Indian castor oil goes to America, and since America is to grow 22% of her needs (27,000 tons of oil in 1959), will exports suffer ? Are there any recent importers (e.g. France for synthetic fibre) ?

Q. 7: Do Indian exporters have any special difficulty in selling? Would any legislation or other incentives help to promote export ?

Q. 8: Are there any complaints in regard to the quality of Indian castor oil and cake ?

Q. 9: Is it advantageous to export castor seeds, or castor oil and cake ? What are the relative prices ?

R. Sankaran : As I have indicated in my opening remarks, the questions are quite interrelated. The figures supplied by various parties indicate the extreme difficulty of obtaining correct data in India. None of the various sources gives the same figures. This has been very well brought out in the tables under Items 1(b) and 1(c) (p. 71) summarised by the Oil Technological Institute, Anantapur.

J. G. Kane : What are the causes for the extreme variations in figures ?

K. S. Murti : Our quoted figures were obtained by addressing the various bodies mentioned. It will be difficult to account for the discrepancies without knowing the methods used for computation. Since the figures furnished by the Central Board of Revenue are based on the collection of customs duty, they might perhaps be more accurate than the others and it is noticeable that production figures given by this body are distinctly higher than those quoted by other sources. The export figures are also likely to be more accurate since there is careful check of all exported material. Of course, the point that emerges clearly is that a major part of the production is exported.

L. G. Kulkarni: There are two distinct sources of collection of statistical data. The Central Board of Revenue depends on factory capacity which may not tally with actual production. The other sources are village officials like *karnams* and *patwaris*.

R. Sankaran: The Central Board of Revenue figures are indeed furnished by all factories coming under the Factory Act, and the reports from such factories are the primary basis for all data on seed, oil and cake. However, they are based not on capacity but on actual crushing. The same figures are also sent for cess purposes to the Indian Central Oilseeds Committee. The computation is not at all satisfactory, since only a percentage of the reports are obtained and can be quite misleading, apart from the loss of revenue by cess. This is especially so for small factories which work sporadically and do not keep records. We have taken up this matter with the Central Board of Revenue but they have not been able to enforce any greater rigidity.

K. T. Achaya: I would like to draw attention to the figures quoted in the notes (Item 1, p. 76) regarding the price of castor oil in the U. S. A. and of castorseed in Brazil. The extraordinary variation of over 100% in the price of both these commodities is rather unusual, and probably suggests that castor has not been stabilised as a world commodity like other oilseeds. What are the causes for such fluctuations in price?

R. Sankaran: We have no proper figures for the price of Indian castor oil, as differentiated from Brazilian castor oil, in the United States market, so that the analysis of price becomes rather difficult. The U. S. A. was one of India's best buyers till 1957, but the failure of the 1958 castor crop resulted in a sharp rise in price of Indian oil. Thus Brazilian oil was available in the U. S. at a lower price than Indian oil. Perhaps also the Brazilian price was a subsidised one and, of course, freight charges for Brazilian oil to the U. S. A. were low. The report of Shri C. V. Mariwala to the Ministry of Commerce and Industry under a project of the International Co-operation Administration which has been quoted in the notes (Item 6g, p. 76) gives a good analysis of the situation. Our main problem is to maintain the U. S. A. as one of our buyers and there is no difficulty in regard to the quality of Indian products. In fact, it was even hinted that buyers in the U. S. A. would prefer Indian oil to Brazilian but like to maintain two sources of supply rather than a single one.

We are tending to forget that the United Kingdom is also a fairly important market for Indian castor oil, taking about 12,000 to 15,000 tons every

year compared to the U. S. A. off-take of some 20,000 tons. The new state trading countries are also emerging as fairly important buyers of castor oil.

B. S. Kulkarni: There is another factor which may influence price. During the building of Brasilia, a large part of Brazilian land was actually bought by U. S. interests. It is possible that big American companies may have their own castor plantations in Brazil, so that Brazilian oil would, to some extent, be an American oil.

R. Sankaran: There is clearly an imperative need to have reliable prices of competing sources of castor oil in the various world markets.

K. S. Murti: The ICOC would be the best agency to collect such data.

J. G. Kane: This information could be had from the Trade Commissioners for India located in various countries.

R. Sankaran: Shri Mariwala had suggested in his report that a Trade Attache be posted in Brazil specifically for the castor industry. Castor buyers in the U. S. A., as I have emphasised earlier, appear to prefer to buy Indian oil if the prices are not artificially raised by speculation and other such malpractices. Undoubtedly, the failure of the 1957-58 castor crop was a significant factor in raising prices. Of course, the effort should be in the direction of reducing prices of castor oil, not by artificial means, but by stepping up production.

B. S. Kulkarni: The reduction of middlemen profits would also help to reduce prices.

K. S. Murti: Solvent extraction of all the cake that is produced will be an immediately feasible proposition and help to increase production and bring down prices. There will be no opposition on the ground of protein quality since castor cake is not an edible oilcake.

N. G. Chatterji: I would endorse strongly Dr. Murti's suggestion. There is no difference in price between milled and solvent-extracted castor cake, which is a factor greatly in favour of solvent extraction. There are no technical difficulties, and some 25 good solvent extraction plants have been set up in the country which could do this job.

V. Samuel: Some 3,500 tons of castor oil just goes to waste at present and could be recovered by solvent extraction. At present normal hexane is being imported, though the recent import in tankers and not in barrels has already reduced the price. In a year or two from now, hexane will be an indigenous product and the price will fall greatly.

N. G. Chatterji: A good part of the price of solvent goes to central revenues as taxes. STANVAC supplies hexane in their own tanks to solvent extraction plants at Rs. 2.60 nP. per imperial gallon.

Purshottam Vallabhji: Excise duty on petrol and industrial solvents is 120%. In 1958, when hexane cost Rs. 3.25 nP. per gallon, the taxes constituted Rs. 1.62 nP.

T. S. Ramaswamy: Another factor which might affect the price of castor oil in the U. S. A. is that the DCO derived from it is tending to compete with tung oil, which has become scarce because it was imported from China.

R. Sankaran: Tung oil is being imported from China into India at the fantastic rate of Rs. 8,000 per ton. This led to establishment of tung cultivation in tea plantations in Assam during the war, when tea was a dwindling commodity. But now these trees are not being exploited. It has been suggested that tung plantations in their own right be set up on a large scale.

To come back to castor oil, we would like to export more oil rather than seed or cake. At present 12% of the oil produced is used in India. The object should be to step up castor oil production to such an extent that even though much more is used in India than at present, there will still be a sufficient exportable surplus.

Regarding the export of castor cake, there appears to be no difficulty regarding quality and standards. In fact, the only difficulty is of the contamination of edible oilcakes with poisonous castor cake.

N. G. Chatterji: During the last two years, there have been many complaints in regard to the presence of traces of castor cake in exported linseed oilcake, and consequently many consignments were rejected. This rejection is based on a microscopic test (described in the notes) by which castor hull particles are perceived as dark fragments even after bleaching. Has it been established that such unbleachable particles are always only castor shell? I sometimes wonder if other business considerations play a part in influencing the so-called chemical examination of the cake.

R. Sankaran: I would like to conclude by pointing out the many factors bearing on the question of castor. This Seminar has done signal service by focussing attention on this important topic, and we hope that other Seminars as well-organised as this will follow and that the organising laboratory will keep the ball rolling. We have gone over the questions of paucity of data, and of measures to increase production like maximum cropping, growing of castor on wastelands and in other ways. Perennial castor is cultivated in Brazil but not in India. This could be grown in selected areas: the cost of cultivation is low, the yield high and ploughing is eliminated. The price must be reduced by keeping down the number and margin of profit of middlemen, and by eliminating speculation and profiteering. In fact, the State Trading Corporation offered to set up a pool of some sort but this was not received enthusiastically by the trade.

Finally, I would again like to repeat that there is need for data of higher accuracy in regard to prices and statistics of production and export. The magnitude of error in the case of the figures for castor is much larger than for any other oilseed.

CONCLUDING REMARKS

K. T. Achaya: I can only hope at the outset that a steady diet of castor oil for two days has not had very drastic effects! Even castor seeds are extremely toxic and I hope that no one has been encouraged to suicide.

I have been asked to summarise the deliberations. The session on castor oil which Dr. Kane led so ably has brought out the encouraging fact that a great deal of research work is in progress in the country. As Dr. Kane remarked, this augurs well for the future of castor oil in this country. It also reveals the trend away from the traditional uses of castor oil in its pristine or slightly-modified form to those uses in which castor oil is modified somewhat drastically.

The session on the processing of castorseed and the utilisation of castor by-products have been conducted in his own inimitable fashion by Dr. Chatterji. I think one of the important points that emerged was the necessity for removing the shells from castorseed if a light-coloured oil was to be consistently obtained. Clearly, the traditional practices in the milling of castorseed are changing over to more scientific lines. Another pointer in the same direction has been the novel method of oilseed processing being developed at the Central Food Technological Research Institute, Mysore, in which both oil and protein are of exceptionally good quality. Indeed, the uses of oilcake in its two traditional ways as manure and as cattlefood have been enlarged to include a third important dimension, that of industrial protein.

Dr. Sankaran brought a wealth of knowledge and experience to bear on his conduct of the session devoted to production, quality and price structure. The need for reliable statistics was repeatedly emphasised and will be echoed by anyone interested in development of this product. It would also appear that castor oil has now entered the world picture and is likely to stabilise in price. Perhaps the competition from the several countries which have recently taken to castor cultivation, though a potential danger to India, will encourage this trend towards stability. It is reassuring to realise that the Indian quality of castor oil is so high as to make it a preferred commodity in world markets and may have something to do with the quality of our seed. Fortunately also castor is an extremely stable oilseed and there is less difficulty in maintaining quality during storage and transport than with other oilseeds.

VOTE OF THANKS

Baldev Singh: In the absence of Dr. Zaheer, who has been called away to New Delhi, it has devolved on me to thank everyone concerned. I would first like to thank Dr. Kane, Dr. Chatterji and Dr. Sankaran for so ably conducting the proceedings and sparing time to come here, despite their many occupations. When organising this Seminar, we did have a few doubts regarding its conduct and utility, but still considered that it would be worth-

while if the effort led to some sustained thinking in this field. At any rate, we have now an integrated picture of the different aspects of the work on castor. I would like to thank the participants in the discussions and the delegates who have attended. I do hope that this Seminar has been of some value to all of you.

REPLY

K. S. Murti: On behalf of the delegates, I would like to thank the organisers for the great efforts made to keep us happy and comfortable. Every worker of this host-Laboratory has come forward to help everyone of the delegates in innumerable ways. We have to also thank them for the sumptuous At Homes, Teas and Lunches.

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